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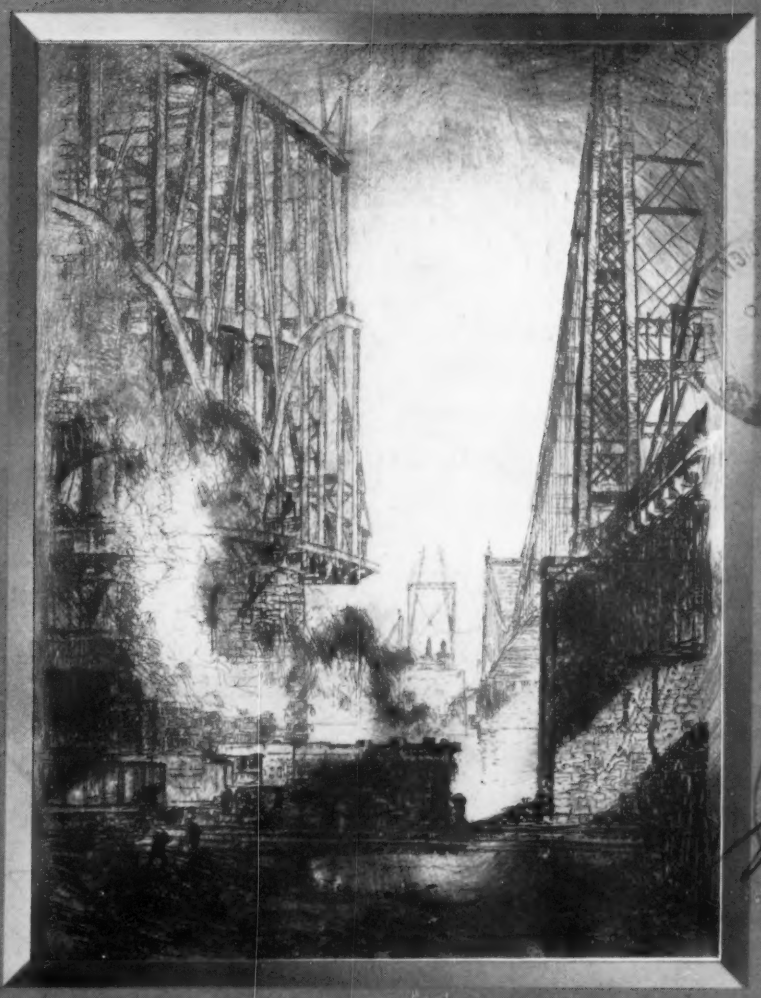

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VOL. IX, NO. 3 APRIL, 1928

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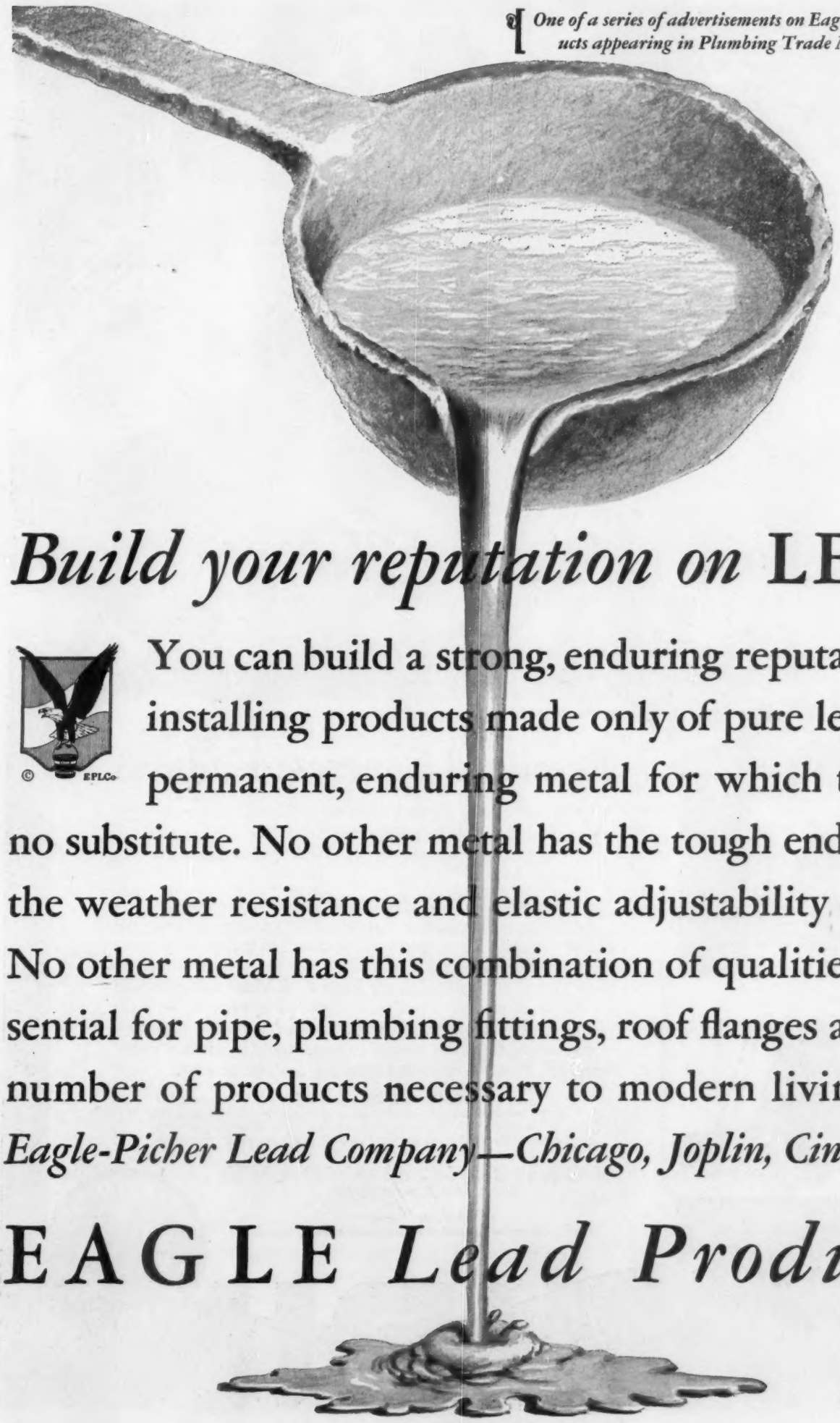

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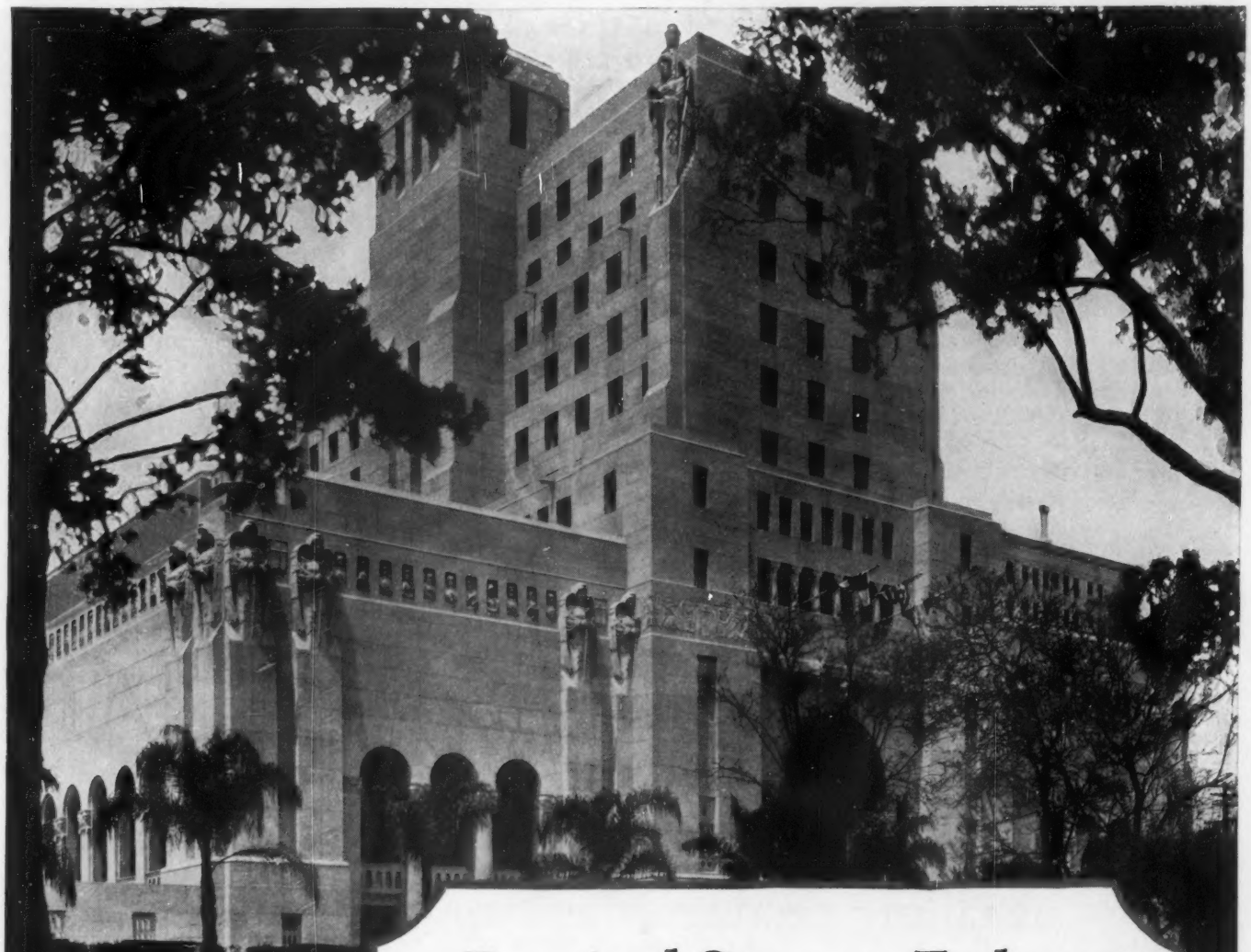

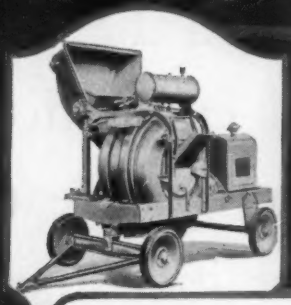

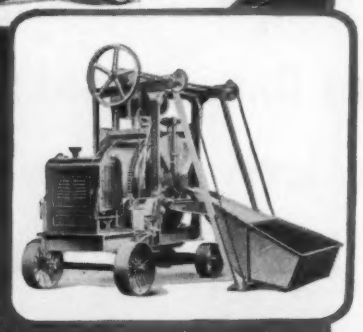

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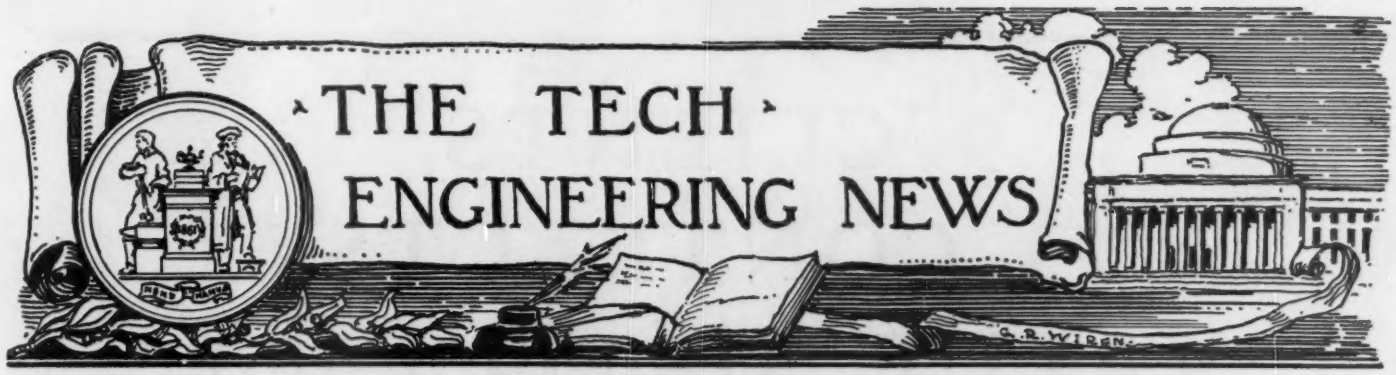

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THE TECH ENGINEERING NEWS

THE PROFESSIONAL JOURNAL OF THE UNDERGRADUATES OF THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

VOLUME IX APRIL, 1928 NUMBER 3

Compounding—A Twentieth Century Art

A presentation of the problems involved in the development of new engineering materials

By FRANK G. BREYER
Singmaster and Breyer
Metallurgists and Chemical Engineers

WHEN the future writes the history of the material progress of the present era, I feel reasonably confident that the first part of the twentieth century will be characterized as the beginning of the age of the compounder of engineering materials.

The nineteenth century was undoubtedly characterized by the activity and great progress of the designing engineer who took already known materials such as brick, mortar, wood, iron and brass, and from them contrived cylinders, pistons, gears, cranks, shafts, and columns. Putting these elements together into assemblies, he made factory buildings, steam engines, bridges, and railroads. At the end of the nineteenth century, the designing engineer had already reached the peak of returns on new design with the engineering materials at his command. He began to realize that his future progress lay in the direction of his ability to get new or better materials from which to make his parts in order that they might stand the tremendously intensified stresses that his assemblies were called upon to meet.

The chemist's type of mind, and then, somewhat later, the type of the physicist, jumped into this breach and built up, and are still building up today, an extensive and intricate compounding art. Through the exercise of this art, new engineering materials with undreamt-of properties have been developed, and old materials have had their bad characteristics lessened and their good ones enhanced to a remarkable degree.

Much of this art was built up by a type of man and a type of work which is not described in the textbooks of pedagogy as being best suited for this purpose. The development was carried on chiefly by men who practiced the simple and homely method of cut and try, in many cases within very narrow limits, and yet with the most astonishing results.

It would be well to stop a moment at this point and outline the definition of a compounder. Practically all of the materials of engineering, with a few exceptions, must be fluid or plastic in their early stages so that they may be poured into moulds or pressed into dies or otherwise made to conform to rigid size and shape specifications. When materials are temporarily or permanently in the liquid or plastic state, it has been found that their ultimate properties can generally be improved for many purposes by the addition, during this fluid or plastic stage, of other materials. The man who purposely puts together different materials in the fluid or plastic state in order to attain certain desired physical properties in the finished material is a compounder.

In the field of alloys, for example, the enormous increase in the desirable engineering properties of the base metal, iron, has been due to millions of cut and try experiments on the addition to iron of all sorts of other things than iron. Equally productive results have been obtained by realizing that the iron of commerce was not a simple substance in itself, but that it could be decompounded into elements which in turn had very unique and valuable properties.

That enormously valuable, and to the present age, wholly indispensable, engineering material, rubber, is one of the most striking examples of what the compounder can do with a single base material. In this case, as furnished by nature, it is of little value until after the compounder has had his way with it. The properties that are associated today with rubber as a useful material depend entirely upon the raw material, coagulated and dried rubber tree sap, being compounded with various ingredients, some of which have an almost completely chemical effect, others of which have an almost completely physical one. The ability of the tread of modern automobile tires to be flexible and permit the use of air as a shock absorber in the tire, and yet, at the same time, to have a resistance to road wear greater than that of steel, is entirely an achievement of the compounder's art.

In the plastic stage of rubber, during the course of its transformation into useful engineering designs, there is incorporated into it several materials. These are sulphur, which is readily soluble in the rubber; carbon black, a very finely divided form of carbon which is a relatively insoluble material; and zinc oxide, also a very finely divided product, which is dispersed in the rubber in still a somewhat different condition from that of the carbon black. These additive or compounding agents give to the base material a phase characteristic, *i. e.*, the base material is no longer one simple homogeneous material like a piece of rock crystal such as quartz, diamond or feldspar. The compounded

(*Continued on page 106*)

Engineering, Chemistry and War

The application of science to the problems of national defense

By MAJ.-GEN. AMOS A. FRIES, U. S. A.
Chief of Chemical Warfare Service

AMOS A. FRIES
Major-General United States Army
Chief of Chemical Warfare Service

MAN has battled for his existence since the beginning of time. In spite of his natural desire for peace and comfort, he has learned that only those who are fit and prepared to demonstrate their fitness, survive, and that this applies to nations as well as individuals. As he has progressed in knowledge, the means he has taken to assure his existence have changed, but the struggle has continued.

Today we no longer battle against disease with charms and incantations, but apply the knowledge of medicine, surgery, chemistry and physics to the problem of getting well and keeping well. It is, however, still a struggle to overcome ill health in spite of the means science has placed at our disposal. Nevertheless, we have progressed considerably, for the casualties in our battle against infections and maladies are fewer than they were in the times when we lacked the knowledge that we have today. Similarly with wars between nations. Wars unfortunately appear to be as prevalent as they were in the past; but popular opinion to the contrary, notwithstanding, they are not so deadly.

This is largely due to science. We may truthfully say that science has humanized war, for with the introduction of new weapons, combatants have been kept apart. It is when man fights man hand to hand that the brutal instincts are unleashed to their fullest degree. In the old days of ax warfare, brutality was supreme and battles ended in the extermination of one side or the other. This type of warfare was humanized by the musket, and in the World War, gas added a still further humanizing factor for it introduced the possibility of regulating the degree of casualty effect. The chemical weapon is the only weapon that can successfully put men out of action without killing.

Mustard gas, the most effective casualty producing agent known, caused only about one-half of one per cent of all our deaths in the World War, although it accounted for about one-fourth of all our casualties. Phosgene in high concentrations will kill and kill quickly, while chloracetophenone will disorganize, harass and put men out of action temporarily without harming them in the least.

We carry on war by means of movement, weapons and protective action. The selection of weapons is obviously of paramount importance. The prime consideration—in fact the sole criterion in selection—is effectiveness. We know of three kinds of weapons today: sticking or thrusting weapons represented by the bayonet and saber, missiles such as the high explosive shell or the bullet, and chemical weapons. Of these the chemical weapon is the newest, so far as its use on a large scale is concerned, and while offering the greatest possibilities, it is still the least understood.

A general discussion of the chemical weapon appears to me necessary in introducing the subject of the chemical and engineering aspects of chemical warfare.

Chemical warfare deals with the direct application of chemicals as weapons. It is concerned with the chemical not as an explosive agent to propel a bullet or fragment of metal, but as the active agent itself to cause casualties by irritation, burning, or asphyxiation, to make ground untenable, to screen operations or lessen the enemy's fire power by creating a smoke screen, and to damage enemy material or personnel by incendiary effect, or otherwise. In general, it accomplishes its object without destruction, except for its use as an incendiary. Men are put out of action and made casualties for a sufficient period of time without being maimed or suffering the after effects that result from thrusting or missile weapons, while ground, habitations or vehicles are made untenable without being destroyed.

The chemical agent is a universal weapon for it is adaptable to all arms. It is a necessary and efficient auxiliary in every operation. Chemicals are used by all combat branches. They are employed in cylinders, Stokes mortars, projectors, in artillery shell, in airplane bombs and by spraying from airplanes, in grenades and in smoke candles.

The wide radius of action and powerful effects now possible with aircraft introduce conditions into warfare hitherto unknown, and radically change the aspect of chemical warfare from the defense or protective standpoint. The taking of warfare into the air is certain to increase the depth of attack generally, and to make installations and troops in rear areas much more vulnerable to attack than heretofore.

In any future big war, gas will probably be employed on a tremendous scale. If so, it will be a part of every operation and it is conceivable the battle areas will be continually drenched with chemicals.

Consequently, the necessity for protection is fundamental. The individual must be equipped with gas mask, and clothed in protective clothing to keep out or neutralize vesicants such as mustard gas. The gas mask provided for our army will give complete and continued protection against any gas we know of today. Nevertheless, we are seeking to improve it further and here are a few of the problems we have been working on. Some of them are in a fair way to solution, some will require considerably more research.

The procuring of a non-shattering eyepiece (lens) which does not become discolored or fogged with age is greatly needed. Such an eyepiece should have good light transmission qualities (at least eighty per cent). The displacement of image should not be greater than four mm. at fifty feet. The cost of such a lens should not exceed fifteen cents each. American manufacturers seem unable to produce such a lens and thus far none has been able to offer such an eyepiece at any price.

One of our present and greatest problems is to build into a gas mask a feature whereby the wearer may talk, issue

commands, and speak over the telephone, at the same time being heard and clearly understood. Some sort of transmission medium which is gas tight, non-corrosive to war gases and the elements, and equal to the rest of the gas mask, in resistance to aging, sturdy, and which will transmit the human voice plainly is desired. The whole must not be too heavy or interfere with the wearer's duties as a soldier. Such duties are using observing instruments, aiming and firing a rifle, using a telephone.

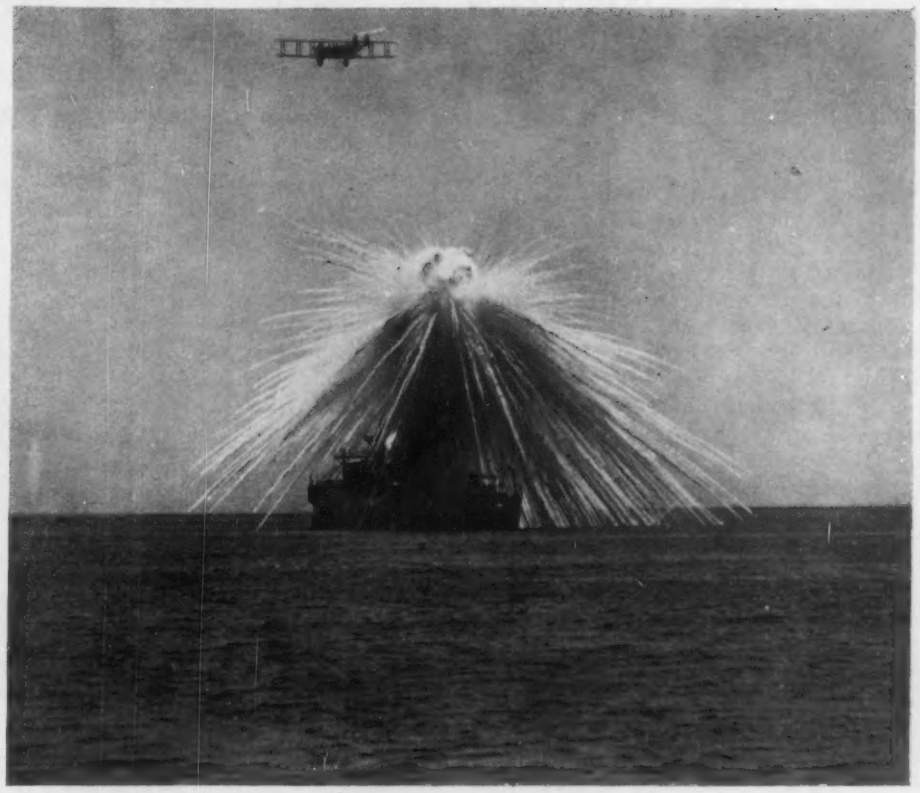
A facepiece material is needed which is light, resistant to age, non-fragile, comfortable to wear, will make a gas-tight fit on the face, is easily procurable and reasonable in cost. Above all other considerations, it must be resistant to war gases.

Rubber most nearly meets these requirements, but rubber deteriorates comparatively rapidly, (although great progress has recently been made in improving its aging qualities), becomes cracked when exposed to sunlight, takes on a permanent set, and is not produced in the United States proper. Leather is the next best material so far tried, but it has not been successfully made mustard gas-proof. It is also less elastic and therefore requires greater care in fitting facepieces made of it. It will probably require a greater number of sizes than rubber.

The valves used in gas masks must have a low resistance to exhalation, but be gas-tight to inhalation. If made of metal they must be non-corrosive in addition to the above quantities.

The present valve is made of molded rubber. In assembling it is necessary to stretch the end of the valve over the exhaust port. Rubber fails relatively quickly at such a point due to cracking. The development of a non-rubber valve is desirable.

The application of chemical engineering to the activities of the Chemical Warfare Service is extensive. In general it may be said that the methods and principles followed and developed by the Chemical Engineering profession as a whole are followed in chemical warfare work very much as in the case of any other chemical industry. The extreme toxicity and the corrosive nature of many of the materials dealt with, however, in many instances, makes its necessary to add considerable in the way of safety factors to what is ordinarily considered a standard practice in other lines of chemical industry. When it is remembered that contact with even the minutest quantity of a liquid like mustard gas would result in severe burning and when it is remembered that extremely minute quantities of mustard gas vapor in the air will cause blisters on the skin, irritation of the eyes, nose, and bronchial tubes, the necessity for an absolutely tight apparatus and thorough ventilation will be appreciated.



PHOSPHORUS BOMB

A direct hit on the *U. S. S. Alabama*

The problem of filling shells with chemical agents is one that has engaged much of our attention. Dealing with toxic irritating or incendiary agents it involves difficulties that although not insurmountable are real and require time and effort for their solution. Moreover, we must devise methods of filling that will be applicable to the large scale production a war would necessitate. It is not enough just to pour the agent into the shell.

The problem in shell filling consists in accurately measuring and transferring the contents of a shell from large (one ton) containers to the individual shell without spilling or dissi-

(Continued on page 114)

A SMOKE SCREEN FOR THE DEFENSE OF NEW YORK

Artificial Climate and Plant Growth

A description of some research leading to a better understanding of photosynthesis and its applicability to plant growth

JOHN M. ARTHUR
Boyce Thompson Institute
for Plant Research, Incorporated

VAN HELMONT about two hundred years ago performed a classical experiment. A willow branch weighing five pounds was planted in a pot of soil weighing when dry about two hundred pounds. The branch took root and grew. It was protected against dust accumulation and only rain water was added to the soil from time to time to maintain a certain moisture content. At the end of five years the tree was removed and weighed. It was found to have gained one hundred fifty-nine pounds while the soil had lost only about two ounces. This pioneer scientist showed by simple experiment that most of the dry weight of a plant does not come from the soil, as might be expected, but from the air and from the water added to the soil. By the year 1804 it had been shown that the substance which the green plant takes from the air is the gas carbon dioxide and further, that green plants in light can use more of the gas than is normally found in air. The energy of light is absorbed by the green plant and carbohydrate compounds; sugars, starches, and cellulose are built up out of carbon dioxide and water. The process is called photosynthesis. It is peculiar to certain living plant cells and ranks with the processes of growth and reproduction in its importance to life. Only green cells of plants have the power of photosynthesis. Fungi and other plants having no green pigment and all animals are parasites in the original meaning of the term; they eat at another's table, the table which the green cells prepare with the energy of sunlight.

There is an average of only three parts of carbon dioxide gas in ten thousand of air; chemically only a trace, yet both plants and animals are dependent upon this supply for their food. Fortunately the exact amount of the gas is apparently regulated, as it does not increase or decrease appreciably over long periods of time. Burning vast quantities of carbon on the earth's surface makes very little change in the total amount in air. Over large industrial centers CO_2 may accumulate locally for a short time, but this change is soon corrected by a slight wind.

It has been found that air over sea water, or winds coming from the sea contain less CO_2. The ocean is no doubt an effective regulator of the amount of gas in air. Its solubility in water increases with a decrease in temperature and this, no doubt, explains the fact that samples of air from the antarctic region may contain less than .02 per cent CO_2. Higher ocean temperatures would operate to increase the amount of CO_2 in air, and fossil remains of palms and other tropical plants in Greenland testify that even the arctic circle once had a tropical climate. At this time the concentration of CO_2 in ordinary air must have been considerably higher, assuming that equational temperatures were the same as now or even higher. With a tropical climate, and a higher concentration of CO_2 and the present intensity of summer sunlight, the growth rate of a number of plants would be greatly increased.

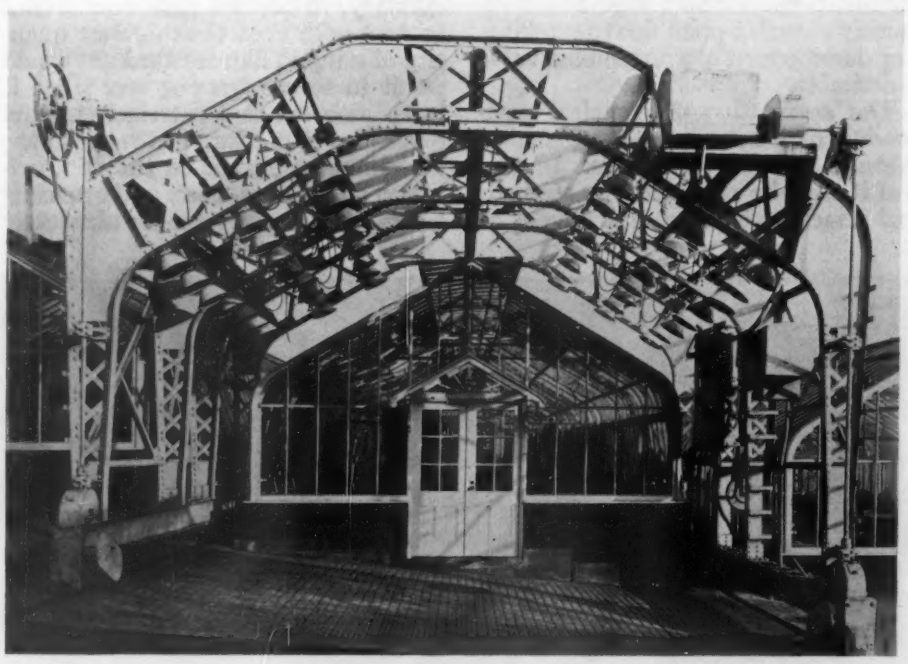
Effect of External Conditions on Photosynthesis

The process of photosynthesis, or carbon fixation by green plants in sunlight, depends on factors other than carbon dioxide supply. Temperature, wind velocity, water supply, intensity and quality of light, supply of mineral nutrients and many internal factors peculiar to species or to individuals may limit the process. Even at its best in nature, photosynthesis is not efficient. Only about one per cent of the total radiant energy falling upon a leaf is utilized in fixing carbon. When light intensity is high, water supply or temperature may limit the process. When light intensity, water supply, and temperature are all optimum, CO_2 supply limits the process. As a result a plant in nature rarely, if ever, carries on photosynthesis at its maximum rate. The result of a given environment on plant growth can not be predicted by studying the effects of a few environmental factors singly. The factors must be considered in their relations as a group and all combinations tried not for a few hours in a laboratory experiment, but all during the life history of a plant and on a production scale sufficient to cancel individual variations. The rate of photosynthesis increases, within certain limits, with temperature. It also increases with carbon dioxide concentration, and again with additional light intensity. Whether these increased rates can be maintained by all plants during their entire life cycles can only be determined by actual trial.

Control of Environmental Factors

It was evident, when these studies were first planned at the Boyce Thompson Institute, that one of the best means of finally testing the effects of each environmental factor on plant growth was to produce an artificial

(*Continued on page 108*)



GANTRY CRANE
Used to supplement the daylight in a greenhouse with a few hours of artificial light at night

Titanium

A resume of the properties and uses of this valuable element

By A. THOMPSON
General Manager, The Titanium Alloy Manufacturing Company

WHILE engaged in the study of Rutile in 1794, Klaproth announced the discovery of a new earth. To the metal of this earth he gave the name Titanium, alluding to the fabled giants of ancient mythology, the "Titans." A few years earlier McGregor, while investigating a magnetic sand found in Menachan, Cornwall, actually discovered Titanium. He named the black sand Menachanite and called the element Menachite. In 1797 Klaproth found that the Titanium and the Menachite of McGregor were identical and the name Titanium was universally accepted.

Titanium belongs to the same chemical group of elements as silicon, zirconium, cerium and thorium. Like these elements it is tetravalent, with a lower valence in some cases and, like zirconium, it is a weak base-forming or a weak acid-forming element.

Until quite recently titanium has always been referred to as a rare element. However, in 1900, Clark gave titanium ninth place in the scale of abundance in the solid crust of the earth, placing it next to potassium.

The important titanium minerals ranked in descending order of distribution are as follows:

(1) Titaniferous magnetites consisting of combinations of magnetite and ilmenite.

(2) Titaniferous hematites, in which hematite and ilmenite are combined.

(3) Beach sand deposits of ilmenite, zircon, monazite and rutile.

(4) Rutile.

Titaniferous Magnetites

The best known and probably largest deposits of titaniferous magnetites are located in the United States. In the United States Government Bureau of Mines Bulletin No. 64, entitled "The Titaniferous Iron Ores in the United States, Their Composition and Economic Value," Joseph T. Singewald, Jr., writes as follows:

"Two deposits in anorthosite stand out above all other titaniferous iron-ore deposits in the United States; these are at Sanford Hill, New York, and Iron Mountain, Wyoming. At each of these localities, in addition to the one enormous deposit, there are smaller but important deposits with the same kind of ore. At neither place has a careful estimate of available tonnage been made, but it is apparent from the known extent of the deposits that the quantity of ore that can be mined by simple quarrying methods alone runs into millions of tons. The ores are nearly pure aggregates of magnetite and ilmenite, the gangue minerals being so subordinate in amount as to be negligible. The average composition of the Adirondack ore corresponds to 62.8 per cent magnetite and 30 per cent ilmenite, whereas that of the Wyoming ore is equivalent to 49.8 per cent magnetite and 40.15 per cent ilmenite. The results of magnetic concentration tests show that the Adirondack ore would yield a concentrate containing less than 7 per cent Ti and the Wyoming ore a little less than 10 per cent. The titanium content of the Adirondack concentrate is low enough to make feasible its mixture with several parts of non-titaniferous ore to make a product low enough in titanium to be used in ordinary blast-furnace practice. The low phosphorus and sulphur content of the concentrate would make it a desirable material for mixing with ores of non-Bessemer grade and high in sulphur. The concentrates of the Wyoming ore are rather high in titanium for this purpose, and it is probable that these deposits will have to await some such process as electrical smelting that will make possible the direct smelting of titaniferous ores. To provide adequate transportation facilities for the Sanford deposit will require the construction of more than thirty miles of railroad over a mountainous country; for the Iron Mountain deposit, only ten miles will be necessary, and the construction will be much easier. In both cases the deposits are large enough to warrant this expense.

To sum up, it may be confidently asserted that the Lake Sanford and Iron Mountain, Wyoming, deposits are important ore bodies that before many years will be furnishing a considerable tonnage of iron ore. The rest of the titaniferous iron-ore deposits of the United States cannot for many years to come be of any value as sources of iron ore."

Ranking as the ninth most plentiful element within the crust of the earth, titanium still remains an element of which we hear little. However, its importance in the field of pigments for use in paints is growing steadily. It is with pleasure that we present this article by Mr. A. Thompson to our readers.

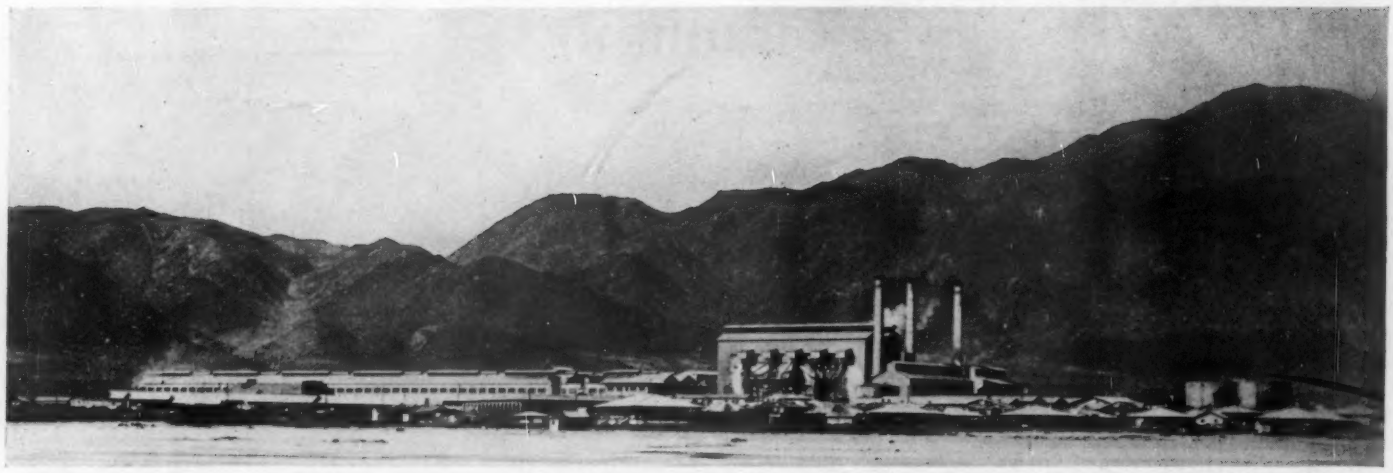
From a commercial standpoint the great advantage of the titaniferous magnetites is their ready susceptibility to magnetic concentration. One very large deposit, that of the MacIntyre Iron Company, located in Essex County, New York, to which Mr. Singewald refers, has been extensively investigated. Over 100,000,000 tons of ore carrying approximately 45 per cent metallic iron and 20 per cent titanic oxide has been proven to exist at this location by magnetic survey and diamond drilling. Concentration tests have demonstrated that from one ton of this ore in the ground there can be produced approximately two-thirds of a ton of magnetic concentrates containing approximately 56 per cent metallic iron, 12 per cent titanium oxide, and very low percentages of both sulphur and phosphorus.

In an extensive blast furnace trial, during the winter and spring of 1914, at the Cedar Point Furnace, Port Henry, New York, as much as five-sixteenths of these concentrates were used on the total furnace burden and a very complete account of the operation of this furnace, which covered a period of approximately six months, was read before the American Iron and Steel Institute, at its October, 1914 meeting, by the late F. E. Bachman, who was in charge of the blast furnace at Port Henry.

From the non-magnetic tailings, after the removal of the magnetite concentrates, were produced approximately one-fifth of a ton of ilmenite concentrates for each ton of crude ore used, the ilmenite being produced by treating the non-magnetic tailings on wet tables of the Deister or Wilfley type. This ilmenite contains approximately 49 per cent titanium oxide, 34 per cent metallic iron, and is very low in other impurities.

It will be noted, therefore, that from each ton of crude ore in the ground there would be recovered two-thirds of a ton of magnetic concentrates, which have been successfully used in blast furnace practice, and one-fifth of a ton of a high grade ilmenite available for the manufacture of various titanium products, leaving approximately only two-fifteenths of a ton of gangue or waste material.

(*Continued on page 110*)



Courtesy American Potash and Chemical Corporation

PLANT OF THE AMERICAN POTASH AND CHEMICAL CORPORATION AT SEARLES LAKE, CALIFORNIA

American Potash*

A review of the potash industry in America since the World War, with reference to the future supply of this important substance

By C. R. MANSFIELD

Geologist in Charge, Section of Areal and Non-metalliferous Geology, Geological Survey, Washington, D. C.

Uses of Potash in the United States

POTASH is one of the soil ingredients necessary to plant life. It is naturally supplied to soils by the slow decomposition of grains of feldspar and other minerals, but the extensive growth of crops in agriculture removes the potash from the soils more rapidly than it can be supplied by natural agencies and causes depletion, which must be remedied by artificial means if soil fertility is to be maintained. Potash is, therefore, a prime constituent of most fertilizers and of all potash materials imported into this country or manufactured here, about 93 per cent† is used for this purpose. Small amounts of potash are also essential for a number of chemical industries such as tanning, dyeing, metallurgy, electroplating, photography, medicinal and miscellaneous chemical uses, and in the manufacture of soap, glass, matches and explosives.

Consumption in the United States

The total consumption of potash in the United States in 1926, the last year for which definite figures are available, was 958,732 short tons of material containing 291,340 short tons of potash (K_2O) valued at $19,514,929. Of these totals 5 per cent of the material containing 9 per cent of the K_2O and representing 6 per cent of the total value was produced in this country.‡

*Published by permission of the Director of the United States Geological Survey.

†Coons, A. T., United States Bureau of Mines and Mineral Resources, 1926, pt. 2, p. 123, 1927.

‡Loc. cit.

§Op. cit., pp. 119, 120.

Domestic Production§

In 1926 crude potash materials amounting to 46,324 short tons and containing 23,366 short tons of K_2O were produced by seven plants in this country.

Courtesy U. S. Geological Survey

FIG. 1

The American Potash and Chemical Corporation (successor to the American Trona Corporation), the chief American producer of potassium salts, also recovered borax and other natural sodium salts as by-products from its plant at Trona (Searles Lake), San Bernardino County, Cal. In 1926 the K_2O equivalent of its product was 58.33 per cent. The salts are marketed as the chloride, KCl. A small amount of potassium salts was produced in Alameda County, Cal. as a by-product in the manufacture of magnesium chloride, but none was sold. The plant of the United States Industrial Chemical Company, Baltimore, Md., was the second largest producer of potassium salts in 1926. The salts averaged 33 per cent K_2O, were mixtures of sulphates, chlorides and small amounts of carbonates and were recovered from the waste from molasses distillation. Potassium salts, chiefly sulphates, were produced and sold at two of the blast furnaces of the Carnegie Steel Company, Pittsburgh, Pa.; alunite was shipped from two localities in Utah for experimental purposes and a small output of potash alum was made from glauconite, greensand marl, obtained in Delaware.

Foreign Supplies

The bulk of the potassium salts used in this country is imported from Germany and France under conditions which practically constitute monopolistic control of the potash market and enable these countries to establish the prices at which potassium salts may be sold in the United States and throughout the world. Deposits of natural potassium salts are known in Spain, Poland, Russia, and other countries. Some of these are being worked, but as yet, with the possible exception of the Polish salts, they do not appreciably affect world markets for potash.

American Potash

The potash industry in the United States probably began in the early days of the country. Notice of it was taken in census statistics as far back as 1850, when the value of the product amounted to $1,401,533. The potash

was obtained by leaching wood ashes. From that date onward the industry declined steadily, especially after 1890, as cheap foreign potash came more and more into use, practically displacing the domestic product. Meanwhile the uses for potash and the demand in this country had greatly increased.

Germany, because of its control of the only great natural deposits of potassium salts then known, became virtually the single source of potash for the world. In 1910 the German Government passed a law, which among other regulations had the effect of invalidating existing American contracts and of sharply advancing prices of potash to American consumers. This action stimulated the United States Government to undertake a systematic search for sources of commercial potash in this country and this search has continued ever since. In 1911 under congressional appropriations the Geological Survey and the Bureau of Soils began coöperative but independent investigations. These researches covered a wide field of possible sources and the results were published from time to time by the two bureaus.

With the shutting out of German supplies during the World War the production of potash in the United States became a grave national problem and practically all sources disclosed by the investigations were utilized. In 1915 a total of 1,090 tons of K_2O was produced in this country by five plants. Under the stimulus of urgent demand and high prices the industry moved rapidly forward and in 1918 a maximum production of 54,803 tons of K_2O was obtained by 128 plants. The nature of the price stimulus may be realized from the fact that the 1914 net price for 80 per cent muriate was about $33 per short ton. During the war years it averaged from $245 to $415 and in 1915 reached as high as $500 per ton. The signing of the armistice checked the advance of the industry and as a result of the lower prices that have since been obtainable plant after plant has had to close.

Searles Lake

The principal productive source of American potash today is Searles Lake, San Bernardino County, California. The interesting geological, chemical, and mineralogical features of this lake have been described by Gale.* The lake in reality is a broad, flat, salt-incrusted surface that occupies part of a desert basin and is generally dry except as it is intermittently flooded by shallow water. Its distinguishing feature is a mass of crystalline salts with an exposed surface estimated at 11 or 12 square miles but extending unknown distances beneath the adjoining locally treacherous playa muds and soils of the basin. The thickness of the salt is reported to average 70 to 75 feet in the main part of the deposit. The salt cake is largely composed of crystalline halite with a surface hard enough to support heavy machinery. In fact, a road and narrow gauge railroad have been built on it from the shore several miles out to a pumping station (see illustration). Within the salt mass below the surface the texture is open enough to allow relatively free movement of the heavy, saturated brine, which normally stands within a few inches of the surface. During the World War several plants at Searles Lake succeeded in producing potash which was marketed, but all were eventually forced to close. The later success of the American Trono Corporation (now the American Potash and Chemical Corporation) in reopening and gaining a place in the present, highly competitive potash market is largely due to the genius of J. E. Teeple, the chemist selected for the task, and to the high quality of the products which he and his associates succeeded in obtaining.

*Gale, H. S., Salines in the Owens, Searles, and Panamint basins, southeastern California: U. S. Geol. Survey Bull. 580, pp. 265–312, 1914.

Courtesy American Potash and Chemical Corporation

SEARLES LAKE, CALIFORNIA

A salt deposit showing road, railroad, pipe line, and power line of the American Potash and Chemical Corporation

According to Teeple,* the plant of the American Potash and Chemical Corporation (see illustration) produces about 85 per cent of the total American output. The brine of Searles Lake contains about 16.5 per cent of sodium chloride, 7.2 per cent of sodium sulphate, 4.75 per cent of potash (figured as potassium chloride), 4.7 per cent of carbonate and bicarbonate (figured as sodium carbonate), 1.5 per cent of boron (figured as anhydrous borax) and 65 per cent of water. The production of commercial potash from such a brine involved many difficult chemical problems. These necessitated tedious detailed studies of the solubilities and equilibria of the various salts of potassium and sodium as they affect each other in different combinations and in different relations. Then there were the questions of removal of water and the separation of the desired salts from those not desired. Solar evaporation, which the climatic conditions of the region would seem to offer as an ideal solution of these problems, was tried but finally rejected in favor of evaporation by steam because of the necessity for careful control of conditions. This treatment, however, introduced an additional difficulty, foaming, which caused the handling of an undue amount of water. This foaming proved to be due to organic matter in the brine. After prolonged investigation it was found that foaming could be controlled by adding soap or something that will form soap.

Teeple summarizes the efforts of his company as follows:

"The result of our work is that next year (1927) we will be turning out a ton of marketable potash or borax every four minutes or less for days, nights, Sundays and holidays. During

(*Continued on page 120*)

*Teeple, J. E. The Economics of American Potash Production. Address delivered at the meeting of the Institute of Politics at Williamstown, Mass., Aug. 12, 1926. Published by the National Fertilizer Association, 1926.

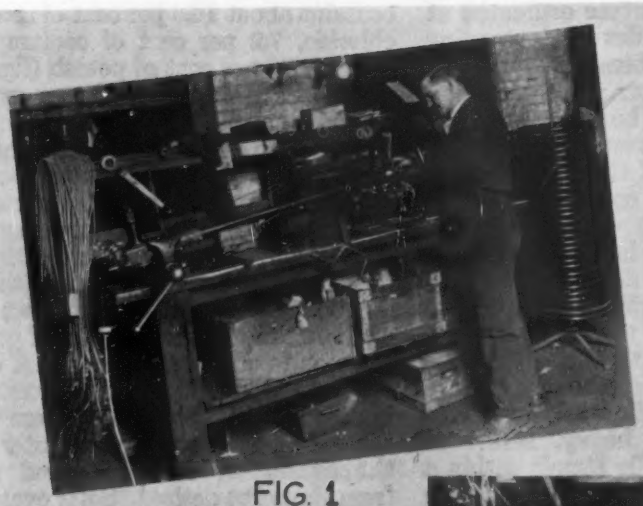


FIG. 1

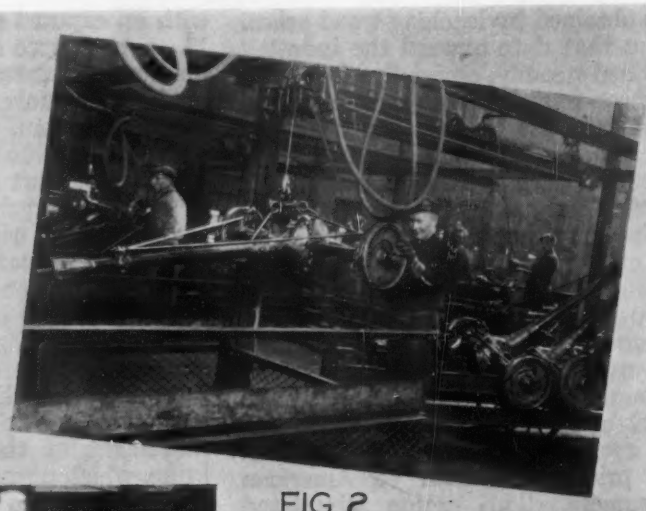


FIG. 2

FIG. 3

FIG. 4

FIG. 5

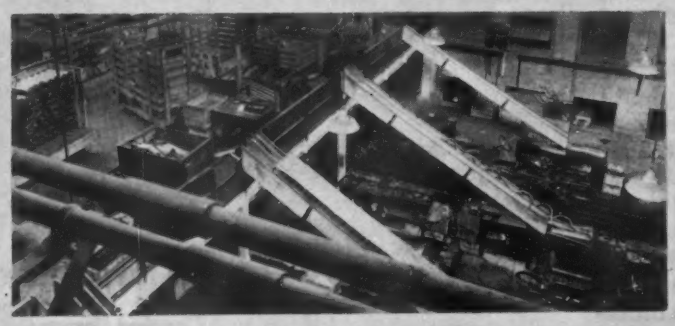


FIG. 6

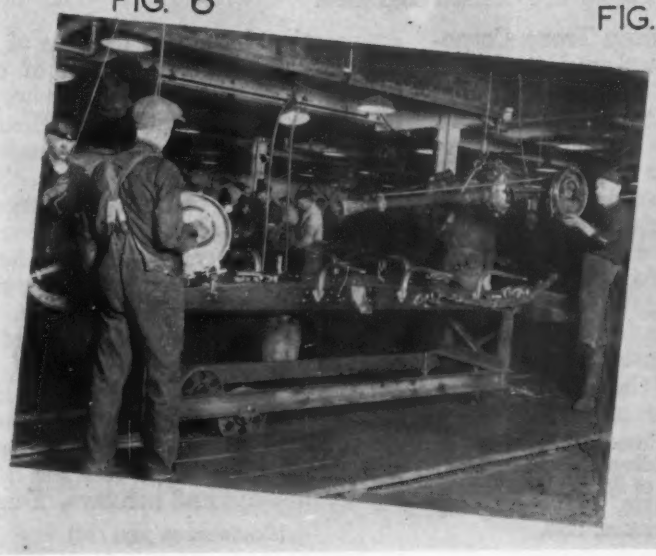


FIG. 8

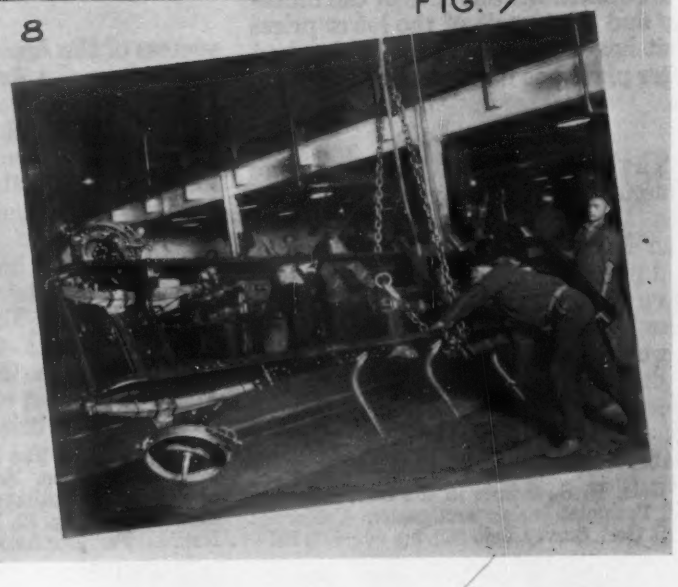


FIG. 7

Automobile Assembling

A description of the methods and equipment used in the mass production of a complicated mechanism

By W. K. Ash
Works Engineering Department
Buick Motor Company

DURING the earlier years of automobile manufacture, each machine was built at a fixed station by bringing its many parts to that location and assembling them into a completed car. This was a slow process, for each man had to perform so many different operations and take so many steps to get the required parts that comparatively few cars could be built each day. As the demand for automobiles increased, new methods had to be found to speed up production and the result is the present day highly developed, progressive assembly line which will be found in every large automobile plant.

The 1928 model Buicks are being assembled on three main progressive assembly lines which occupy a ground floor space of 63 feet wide by 1100 feet long. The lines are spaced 13½ foot centers and have two stock trucking aisles, one on either side of the outside lines. Mezzanine floors are located at convenient points throughout the length of the line, on which stock is carried and many subassemblies made similar to that shown in Fig. 1. A three-story storage building is located on each side of the assembly lines, in which the major part of the required stock is carried. An important feature of uninterrupted assembly is having stock on hand and in its proper place at the time when it is needed. To accomplish this, gasoline tractors, electric trucks and conveyors are used. The tractors are used for comparatively long hauls of 1,000 feet or more, in which trains of five to ten trucks, carrying all kinds of material, are brought from the different manufacturing plants to the above mentioned storage buildings. All parts manufactured within the plant are inspected in the plant in which they are made. The material bought outside is inspected when received. Some material, such as springs and electrical equipment, gets 100 per cent inspection, while other parts, only a certain percentage of the shipment, is inspected.

As material is received and inspected, it is placed in containers of standard size and suited for the part contained. There are four sizes of wooden woven baskets; namely, 22 by 12 by 18 inches, 24 by 16 by 11 inches, 28 by 20 by 18 inches, 32 by 24 by 22 inches. Steel pans are 16 by 18 by 3½ inches. Skids for springs, etc., are 34 by 48 by 12 inches. These containers are filled with a known number of parts and placed on trucks. The trucks are made up into trains and the stock so arranged that, by making a trip over the line, material to meet the requirements of two days' run is delivered to each station on the line. Should a change in schedule occur so that two days' supply should not be needed at the station, the stock is returned to the storage and left on the truck ready to go on the next trip over the line. By this method, material is counted and handled only once. Electric trucks, mainly of the lift platform type, are used for similar service but in places where the distance to be traversed is short. Conveyors are used for some of the heavier and more bulky items, such as motors, axles and sheet metal parts. A description of three of these conveyors follows.

All enameled sheet metal parts are finished on the second floor of a building separated from the assembly line storage building by a street 100 feet wide. A bridge spans this street, connecting the second story of each building, and carries two single strand chain conveyors of the pusher dog type. The finished enameled parts, such as front and rear fenders, side aprons, mud pans, fender wings, and dozens of smaller parts, are inspected as they are taken from the continuous enamel conveyors and loaded on trucks which are pushed by hand about 30 feet to the pusher conveyor which carries them over the bridge and about 50 feet into the storage building where they are left until delivered to one of the mezzanine floors over the assembly line.

A similar conveyor, but running in the opposite direction, returns the empty trucks. The chain for these conveyors is what is known as a combination chain made with alternating malleable iron block links and steel side bars of 6-inch pitch with ¾-inch pins. A single 3 h.p. motor, 1200 r. p. m., drives these conveyors, the reduction being accomplished through a D. O. James spur gear reducer and two sets of spur gears. The conveyor chain has double knockover pusher dogs carried on 3½-inch diameter single flanged rollers running on angle iron track and spaced 12 feet on centers. The double dog is required, inasmuch as the conveyor travels both up hill and down as it passes over the bridge, thus part of the time pushing its load and part of the time retarding it. The speed of each conveyor is 12 feet per minute with a capacity of 60 trucks per hour.

The second conveyor carries axles, alternating front and rear, a distance of 918 feet, passing over a railroad track and moving during its travel in both a vertical and a horizontal direction thus requiring what is called a transverse joint in the chain. This chain is made of malleable iron links, 6-inch pitch, with ⅝-inch pins and having a two-wheel Timken bearing trolley every seven feet, from which the axle is suspended. This conveyor is of the overhead type and runs at a speed of 37 feet per minute, carrying a total load of 16 tons, exclusive of the chain itself, and is driven by a three h. p., 1,200 r. p. m. motor. The reduction in speed is taken care of by one set of cast steel bevel gears and a mill type, spur gear reducer, ratio 62½ to 1. The conveyor is loaded by a pendent type air hoist and unloaded by a hand propelled crane which travels parallel with the conveyor and carries a pendent type air hoist which travels at right angles to the conveyor. Axles from the conveyor are unloaded to trucks, placed in storage and pushed by tractor to a mezzanine floor as needed. Fig. 2.

The third and most prominent conveyor carries motors a distance of 3,500 feet, passing in its travel over three large factory buildings, two streets and a railroad track. This chain is of the same type as the axle conveyor, except much heavier and of 8¼-inch pitch. Transverse joints are located every 4 feet, 1½ inches, but motors are spaced 8 feet, 3 inches on centers. Fig. 3. There are, on this conveyor, 435 motors having a combined weight of 174 tons, exclusive of the conveyor itself. A 10 h. p. motor, 1,200 r. p. m., operates this conveyor at a speed of 20 feet per minute, thus delivering to assembly storage 1,300 motors every nine hours. This conveyor is loaded by pendent air hoists traveling on I-beams at right angles to the conveyor. The motors are taken directly from the final test stand where they have been thoroughly tested and inspected. The unloading is accomplished by lowering onto gravity rolls which deliver the motor to a plate on the floor, from which it is carried to storage by a gasoline lift truck.

Transmissions are delivered to this same storage room on skids carried by electric trucks through a tunnel under a street, a distance of about 500 feet. The transmission is then assembled to the motor (Fig. 4) and is taken by a hand-lift truck to a short cross conveyor from which it is lowered by a horizontal air hoist, 12-inch diameter, 3-foot stroke, compounded 4 to 1, to the assembly line (Fig. 5).

The number of stations on assembly lines are as follows:

First assembly, frame upside down, 5.

Second assembly, frame turnover to steam clean, 10.

Third assembly, oven to body drop, 8.

Fourth assembly, body drop to end of line, 11.

The total number of parts assembled to a car on the line is 1,350, of which about 200 are standard parts. Screws, nuts, bolts, and washers make up the remaining 1,150 parts. The largest of these pieces is the motor and transmission subassembly, weighing about 1,000 pounds, while the smallest are lock washers, 2,900 of which are required to make one pound.

On each line there are two inspectors of riveting, two inspectors in the second assembly, two inspectors in the third assembly, three inspectors in the fourth and fifth assemblies. In all cases, they inspect for defective workmanship.

Starting with the first assembly the frame subassembly forms the base on which the whole automobile is built and this is first brought from storage a distance of about 200 feet, piled on trailer trucks and drawn by a gasoline tractor. From the trailer, a frame is removed and placed bottom side up on a specially constructed, four-wheel, all steel truck and manually pushed to the first station of the assembly line. By station is meant a place along the assembly line to which stock is brought for storage until used. There are four main ways that stock is brought to the several stations: first, by power driven conveyors which include motors with transmissions attached, gas tanks, batteries (Fig. 17), wheels (Fig. 12), and bodies (Fig. 13); second, by gravity conveyors that include radiators, rear fenders (Fig. 14) and lamps (Fig. 15); third, by chutes that include brake shafts, mufflers, battery boxes, exhaust pipes (Fig. 8); fourth, by trucks, either manually or power driven, that include springs, axles, steering wheels, hoods; besides steel containers of different sizes which hold the smaller parts that have been inspected, weighed, counted and stored in them when received.

The first and second stations are known as riveting stations and, therefore, have forges for heating the rivets conveniently located. These forges are provided with compressed air for forcing the draft and are enclosed in a hood from which a stack removes, by natural draft, all fumes and smoke. Small pneumatic hammers are used for driving the rivets. At these stations are riveted step hangers, front fender brackets, snubber brackets, etc., thus making a strong rigid structure on which to assemble the many parts of the automobile. Three of these double riveting stations are required to keep each assembly line running to full capacity. The truck bearing the chassis frame is next pushed forward to receive the four snubbers and then to station 3 where the front and rear springs are secured, after which follow stations 4 and 5 where the front and rear axles are dropped in place from a mezzanine floor (Fig. 6), the lowering in each case being done by a 6-inch diameter, 3-foot, 6-inch stroke, horizontal air hoist, ratio 4 to 1.

A chain suspended from an overhead vertical air hoist is quickly wrapped around the frame, which lifts it clear of the truck, allowing the frame to be rotated 180 degrees (Fig. 7) and moved forward along an I-beam monorail about 20 feet and lowered right side up onto a conveyor, this being the first station on the second assembly. The truck which has carried the chassis frame to this point is returned to the first riveting station to start over again.

Through the next 165 feet of the assembly line, which include ten stations of second assembly, a steam cleaning station (Fig. 9), painting stations (Fig. 10), drying oven and eight stations of third assembly, a conveyor is the motive power. This conveyor is a single strand, all steel chain, having ½-inch by 3-inch steel side bars, of 6-inch pitch, and 1⅜-inch pins at articulating points. Spaced along the chain at 16½-foot intervals are three four-wheel carriers, or trucks. These carriers have a malleable iron frame and are mounted on four 5-inch diameter, single flanged, cast-iron wheels, with 1-inch shafts, spaced 10 inches on centers. The wheels roll on angle iron tracks. The forward truck of the three carries the front axles, while the two rear trucks are spaced to take the rear axles, one used for the standard, or 114-inch wheel base models, the other to take the master, or 120-inch and 128-inch wheel bases. These trucks are bolted to the chain by steel angles known as K_2 chain attachments. There is room for 34 chassis frames on this convoyer at one time. It has a variable speed of from 9¾ feet to 12 feet per minute. The drive consists of two master cast iron gears, mounted on a 5 15-16-inch cold rolled steel shaft on either side of the chain sprocket and engaged cast-iron pinions. A second set of gears connects directly to the slow speed shaft of a spur gear speed reducer, ratio 34 to 1. The gear of the second set, mentioned above, carries a breaking pin which acts as a safety device to protect against a serious breakdown in case something gets caught to cause excessive chain stress. A flexible coupling connects the speed reducer to a 10 h.p. motor. The complete drive is mounted on a cast-iron frame which is securely anchored to a shallow concrete pit. The terminal sprockets are cast steel 16-inch P.D., having four actual teeth with four other teeth omitted because of the chain construction. The foot shaft of this conveyor is carried in 30-inch adjustable takeups which are ample to take care of the chain variation. That part of the conveyor which passes through the drying oven is elevated to allow for storage and cross-overs underneath.

As the three chassis assembly lines emerge from the drying ovens, the gas tank and battery are secured to the chassis. A single, double-strand chain conveyor, of the suspended tray type, supplies the necessary batteries. Fig. 17 shows this conveyor passing over the assembly lines with three legs, taking a downward turn near the floor at which points the batteries are taken off as needed. The empty trays are replenished with other batteries as the conveyor moves through a storage department at the side of the assembly lines. Four batteries are carried on a tray. A 5 h.p. motor, 1,200 r.p.m., drives this conveyor at a speed of 30 inches per minute. The speed reduction is accomplished through one chain drive, one set of spur gears and a spur gear reducer, having a 20 to 1 reduction ratio. Just beyond the battery conveyor is located a series of wheel conveyors. Fig. 12 shows this equipment, there being two cross belt conveyors, one above the other, and two double-strand chain conveyors, one on either side of each chassis assembly line and parallel to it. The wheels and tires are assembled in the basement of the storage building shown at the left of Fig. 12, loaded by a short gravity roll to a 24-inch belt conveyor which, in turn, delivers at right angles to the chain conveyor which carries the wheels forward and lowers to the floor line where they are discharged through a short inclined runway, or chute, to a point readily accessible to the assembly line. An electrically controlled cut-out switch is located in the chute, which automatically stops the conveyor when the wheels are fed too fast. A push button then is used to again place the conveyor in motion. Each set of conveyors supplying an assembly line, *i. e.*, two belt and two

(*Continued on page 126*)

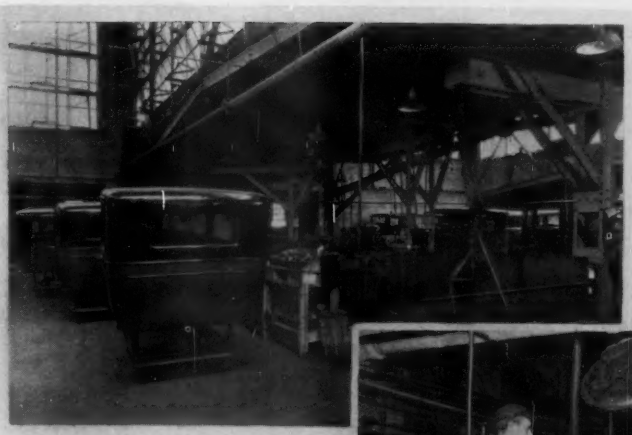


FIG. 13

FIG. 16

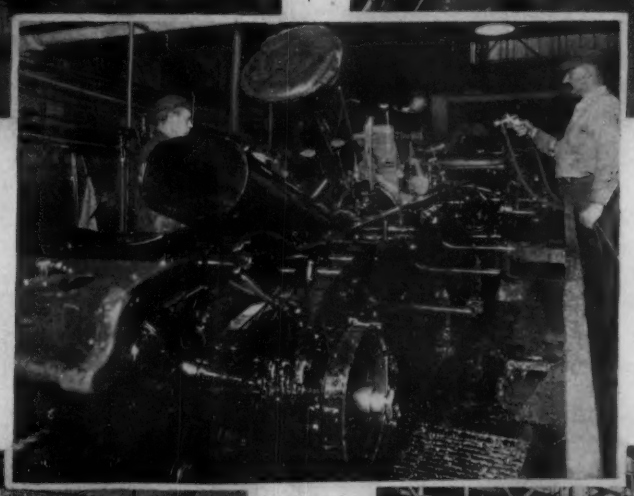


FIG. 10

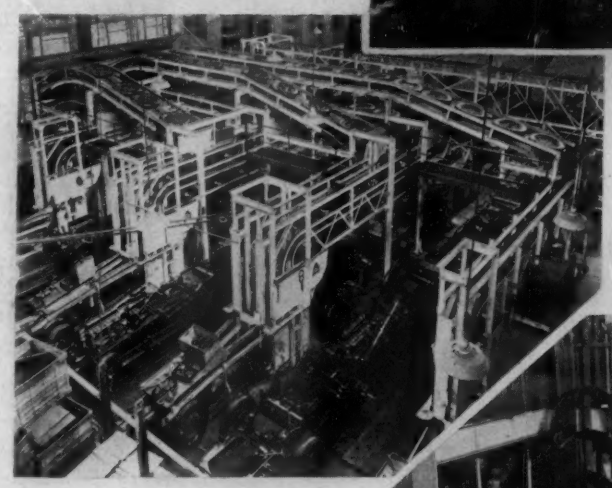


FIG 12

FIG. 17

FIG. 14

FIG. 9

FIG. 15

Technology's New Gliders

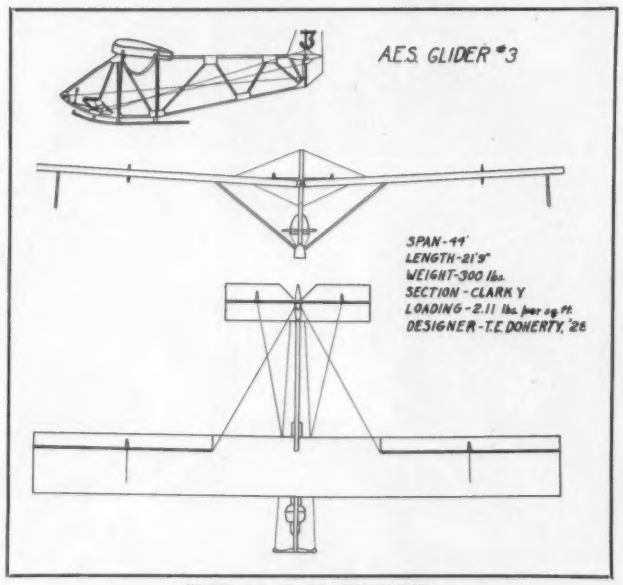
A description of gliders now being built by Technology undergraduates for competition with those of German design

By J. C. REDDIG '29
M. I. T. Aeronautical Society

THE Aeronautical Engineering Society has again taken up its work with gliders, for the purpose of further experimentation with gliding and soaring flight and its problems. Back in 1922, when interest in gliding was at its height, Technology, through the Society, was the only American competitor represented in foreign gliding meets. At that time, two gliders were designed and constructed, wholly the work of student members of the Society. After test flights had been made from local hills, these planes were shipped abroad, and entered in the contests held at Clermont-Ferrand in France and at the Rhöen in Germany, manned by a crew picked from the Society and piloted by Mr. E. T. Allen. A very creditable performance was given, and the expedition returned with a bronze medal awarded the Society by the Aeronautique Club de France.

In the spirit of "carrying on" the work which was thus so well started, it was decided that a new glider should be built. Design work on this was immediately started, and it soon became apparent that two planes were needed, the first, a rugged training ship for experimental work, and to permit the training of glider pilots, and the second, a more refined type of machine which will be used for competition purposes. The first of these is almost completed, and the second is soon to be begun.

The training ship is a bit heavier and more rugged than the second "competition" ship will be, for it is expected that it must weather some rough handling. It has a simple open-frame truss for a fuselage, which, while not the most efficient aerodynamically, still offers a maximum of protection to the pilot, for he is not cooped up in a box type fuselage in case of a bad landing. This open frame also is better as regards cost, ease of construction, and repair. A single semi-cantilever wing has been built, having two routed solid wood spars and 24 ribs. The whole ship is wood, with the exception of sheet steel fittings and steel tube wing struts. The landing gear consists of a simple ash skid with shock absorbers.



THE M. I. T. GLIDER

Five wing ribs were tested to destruction, each of different design and materials, in selecting a type for use in the ship. These were made from ¼ inch x ⅛ inch spruce stock, joined by $\frac{3}{32}$-inch plywood gussets and having a plywood leading edge. Pasteboard gusset construction was tried, and it was found that the members of the truss would fail before the pasteboard failed, but this construction was abandoned for other reasons. The chosen rib was tested to 135 pounds total distributed load in high incidence, and tested to destruction in medium incidence, failure occurring in several places almost simultaneously at 236 pounds distributed load. This rib weighs 3⅜ ounces, and is 5 feet long. It is of some significance to note from the files of the Society that the ribs of the 1922 planes weighed 4 ounces and failed under 190 pounds (Fig. 2).

In testing, the rib was supported upside down on two dummy wing spars, and confined between a board and a piece of heavy plate glass to prevent its twisting out of a single plane. The glass permitted inspection while the rib was under load. It was assumed that all loads would be on the lower capstrip, those on the upper surface of the wing being transmitted through, by the sewing which held the fabric to the upper surface. Loops of rubber bands taken from standard shock absorber cord were hung along the lower edge of the rib, and an iron bar was slipped through the lower ends of all these loops. The bar was then pulled downward until the rib failed, a tension balance showing the load on the bar, or the total distributed load on the rib. The rubber bands were distributed along the chord of the rib according to the Army loading diagrams for high and medium incidence conditions of the wing, thus placing most of load, hence most of the rubbers nearer the leading edge of the rib, and fewer toward the trailing edge (Fig. 1). These ribs were a part of the design of the plane, the work of Mr. T. E. Doherty, '28, and they were tested under the supervision

(*Continued on page 114*)

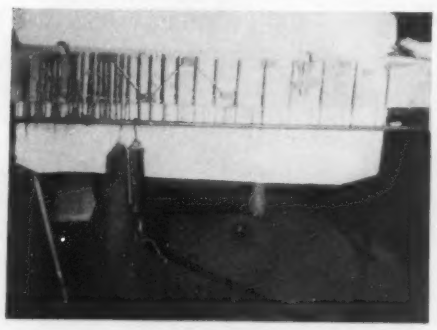


FIG. 1

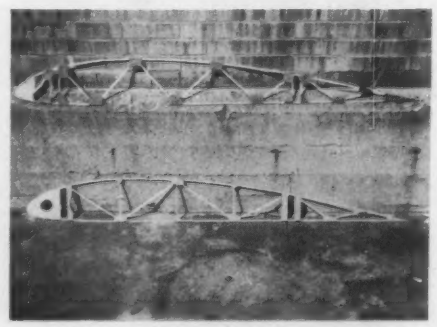


FIG. 2

Editorials

NOTHING IS IMPOSSIBLE

It was one of Conan Doyle's characters who repeatedly insisted that "Nothing is Impossible." To one who had lived in the time of Caesar, recalled to life today, it would seem that the statement was quite true. Now we insist that it is entirely a matter of place in time. Two thousand years ago it was impossible for man to fly, much less fly across the Atlantic. Today . . .

Likewise, at present, it is impossible for man to fly to the moon, yet who will say that two thousand years from now it won't be possible. No, we have seen too many prophecies concerning man's ability turn out to be false, for us to say what he can do or what he can't do in the future.

But what about the present? A man, having practically no technical education, invents a motor using the earth's magnetic field as power, and intends to build one large enough to propel an airplane, not to mention the fact that he has made application for corporation papers. Now when the best informed men in the electrical field say that this is an impossibility, we believe them. They know that at the present time there is not enough power in the earth's magnetic field to run the most perfect motor man has yet built which would be large enough to propel an airplane. So we do not hesitate in saying that it is now impossible to derive useful power from the earth's field, and we sincerely hope that not too many of the present-day pseudo-scientific public will be taken in.

OUR NEXT PRESIDENT

For years scientists and men of the engineering profession have lamented the fact that we almost invariably chose soldiers, or politicians (statesmen, if you prefer) to head our government. In the words of Arthur D. Little, "Office does not seek the man in the laboratory, and candidates are not pictured as engaged in any activity that might suggest a superior intelligence. We see in the ranks of science, knowledge without power, and in politics, power without knowledge." Is there any professional man that this state of affairs has not rankled?

At last there is some hope. It is entirely possible that we may have as nominee for the presidency an engineer of outstanding ability.

As members of an institution of engineering, we are hoping first: that Herbert Hoover will be nominated for the presidency; and second, that he will be elected. We also feel confident that he will have the support of every professional man.

Incidentally, were he to be elected, it would renew our faith in the masses. It is often hard to convince ourselves that when it comes to voting, or anything else for that matter, any thought is displayed by the majority of people. Though this would not necessarily prove us wrong, we could find some satisfaction in fooling ourselves to that extent.

We, then, are hoping to see Hoover as our next President, and feel confident that as President he would do credit to the engineering profession.

THE COVER

This month our cover is an etching by Mr. Otto Kuhler, of Pittsburgh, depicting bridge building. Mr. Kuhler is an industrial artist and his work is of unusual interest and value. We take pleasure in presenting this cover, and it is a forerunner of a series of etchings by him.

Mr. Kuhler was born in Germany in 1894, of a family of steel makers. He has had a very varied life, having been in succession a sailor, a designer of automobiles, an advertising manager, and a construction engineer. He is now devoting his time to the more romantic side of engineering in portraying technical subjects such as our cover for this issue.

KNOWLEDGE PLUS WISDOM

In our February issue we featured an article by Mr. William E. Nickerson '76, entitled, "Knowledge Plus Wisdom." This article was substantially Mr. Nickerson's Aldred lecture to the Seniors and graduates. Mr. Nickerson has made some valuable suggestions, and we feel that a letter which was received from Mr. David Wesson '83, commenting on this article, may be of interest to our readers, so we are passing it on in full.

"I have just been reading with much pleasure Mr. William E. Nickerson's paper on "Knowledge Plus Wisdom", with which I heartily agree.

Professor Tyler's article on Greater Technology in *The Tech* of January 16 seems to furnish a fitting introduction to Mr. Nickerson's very timely words.

In the days recalled by Professor Tyler our whole time was devoted to the acquiring of knowledge. The knowledge we acquired pertained almost entirely to things physical, chemical, mathematical and material. Every moment not spent in the acquiring of this knowledge was considered a sinful waste of time. The humanics were entirely left out of our course except such as we acquired by close contact with our inspiring professors. And this meant very much to us because with the small student bodies of those days the personal contact between professor and student was something which, with the large classes of today, has become mostly a thing of the past. When we were turned loose to make our way in the world, very few of us, unless we had acquired it naturally, had any knowledge of human nature or the relative value of our services.

In fact, the professors of those days frowned down upon anything which looked like commercialism. How they ever expected young men to go forth and settle down and raise families on a strictly professional basis is beyond my comprehension.

The net result of the training of those days was to turn out young men who could handle materials to the Queen's taste, but had little idea of how to deal with their fellow men. If we could have had a Chair of Humanics as suggested by Mr. Nickerson we would have gone forth into life much better equipped and avoided the many mistakes which have taken us years to overcome. I am strongly in favor of a course in Humanics at the Institute. If we could obtain a man like Mr. Nickerson to occupy the chair it would be an ideal arrangement. A lecture course given by a number of men like Mr. Nickerson, who have had the experience and acquired wisdom and could pass some of it along in a series of talks to the students, would be the next best thing. President Walker used to say that boys went to college to play, but men went to the Institute to work. From what I have been able to observe there is more play than there used to be in the early days of the Institute. But we can not overlook the fact that the human contacts obtained in the college life of the goneby days had much to do with giving the college student knowledge of his fellow men which is something to be greatly desired as an addition to technical training.

Yours sincerely,

(*Signed*) DAVID WESSON '83."

The Engineering Field

Abstracts from the leading professional and trade journals

A Reinforced Concrete Railway Terminal is at present under construction in Limoges, France. The building is 310 feet by 250 feet and is built over ten tracks. Upon completion the concrete will be faced with soft white limestone, and it is planned to have pink hard limestone in the cornices. The main hall is faced on three sides by thin walls and on the fourth by a six-story building with an eleven-story tower. The center section of the hall is composed of four groups of columns, each group in turn having four columns. Each group supports twin arches with spans of 86 feet, 10 inches. The roof spanning consists of structural steel framework covered with blue slate, and all of the flat or low parts of the roof are covered with $\frac{13}{64}$ inch lead sheeting. The eleven-story tower consists of square slabs 14 inches thick supported by four beams resting directly on the column. The building proper uses concrete floors throughout. Due to the difficulty of obtaining sufficient depth for large stresses some floors are designed as slabs 1 foot thick, while all others are designed as "T" beams.

An Island Airport for Portland, Oregon is now under construction. For a great many years Swan Island at the head of the ship channel has served only as an obstruction, and being low and marshy was of no use to anyone. When the question of a municipal aviation field was raised the plan to reclaim Swan Island was formulated. For many months dredges and "sand suckers" have been at work and soon Portland will have an airport 6,700 feet long and 1,220 feet wide which will be connected to the mainland by a 350-foot causeway. Between the island and the mainland in the line of the old channel there will be a still water basin one mile long and 700 feet wide, very handy for the maneuvering of seaplanes. The drainage of the field has been well taken care of as the center section has been raised about 22 feet.

The field is well located both from the standpoint of the pilot and of the city of Portland. It will be easy for the pilot to locate, as it is right at the confluence of the Columbia and Willamette Rivers and handy for Portland, as it is but a ten to fifteen-minute run to the heart of the city. When completed the field will cost about $2,700-000, and will be operated by the Port of Portland.

Pre-wetting the Embankment Material of a Gravel Fill Dam is a recent development that was employed in the construction of the dam on McKay Creek, near Pendleton, Oregon. The material was wet before excavation by means of pumped water applied by the irrigation method. The quantity of water was varied to suit the material, so that upon reaching the dam it had the proper consistency for maximum compacting.

This system holds a distinct advantage over the generally adopted method of spreading the material dry and then sprinkling on the embankment in that a more homogeneously moist mixture is obtained. The handling of the wet material constitutes a veritable mixing process, so that when put into the embankment it is not only pre-wetted but also pre-mixed with water. The proof that good compaction is secured by use of this process lies in the fact that the almost negligible settlement of one-half inch was recorded. The cost of one cent per cubic yard for pre-wetting is about the average of the recorded costs for sprinkling.

An indication of the confidence of the engineers in their embankment material and in the filling methods employed is the fact that the unusually steep upstream slope of one on two was used. The construction was thus carried on at a saving of approximately $500,000.

Revetments in the Mississippi Flood Area are now being seriously considered as the best tool of the engineer to correct the troubles arising in connection with that great river. In 1881 the first revetment work was begun, consisting of brush-and-wire mattresses made from the willows along the banks of the river. However, in 1893 matters became complicated as the supply of willows was limiting operations to but fifteen miles of work per year. Up to the present date different types of mats have been experimented with, and finally concrete mats have been designed and used effectively.

The articulated mats are made upon a quarterboat equipped with machinery to lower the mats to the bottom of the river. The mats are made of slabs 3 inches thick, 11½ inches wide, and 3 feet, 11 inches long, reinforced with wire mesh cut into 25-foot lengths, so that twenty-five slabs are cast in each mat unit. The mats are cast one on top of another, separating each layer with one or more sheets of Kraft paper. When operating, the plant discharged about five hundred batches of concrete per day, running two ten-hour shifts. The mats are laid so that a section 140 feet along the shore and 200 to 300 feet out into the stream is formed, reaching beyond the toe of the slope which is to be protected.

During the season of 1927 to 1928 an amount totaling 67,000 squares was laid. It was expected the work with concrete would run to a higher cost than that with willow. However, the last reports show that willow mats cost $300,000 per mile to lay, while the concrete amount to but $225,000 per mile.

Celluloid-Rubber may be deposited by the evaporation of a solution

Courtesy Electric Traction

TRACKLESS TROLLEY FOR MANILA

It is without windows as none are used in the Islands

of rubber and celluloid in cyclohexanol, known as hexaline. The rubber and celluloid are first dissolved separately, and then the solutions brought together; when this resulting solution is evaporated on a glass surface, a fine celluloid rubber film is deposited.

Hexaline is peculiarly fitted for this use. It, or its conversion products, are capable of dissolving both crude and vulcanized rubber. Its solvent action is greater and more perfect at ordinary temperatures than other solvents. It is a neutral water-white liquid and does not dissolve readily in water. No discoloration takes place on standing; it is very stable, even at the boiling point. It evaporates without residue. Like amyl alcohol, hexaline has a high dissolving capacity for solid and liquid hydrocarbons, fats, oils, resins, waxes, etc.

The discovery of celluloid-rubber came as the result of a desire on the part of research chemists to unite two dissimilar substances to give the best qualities of both. It is one of the few cases in which they have succeeded. It is as yet a laboratory curiosity, and its use will be determined upon additional research.

Compressed Gas has successfully been used in motor vehicles, according to a report received at the World Motor Transport Congress, in London. Experiments were made on a truck equipped with six steel cylinders containing coal gas under a pressure of 150 kilograms per square centimeter. The French company carrying on the experiments developed a special carburetor for mixing the gas with air.

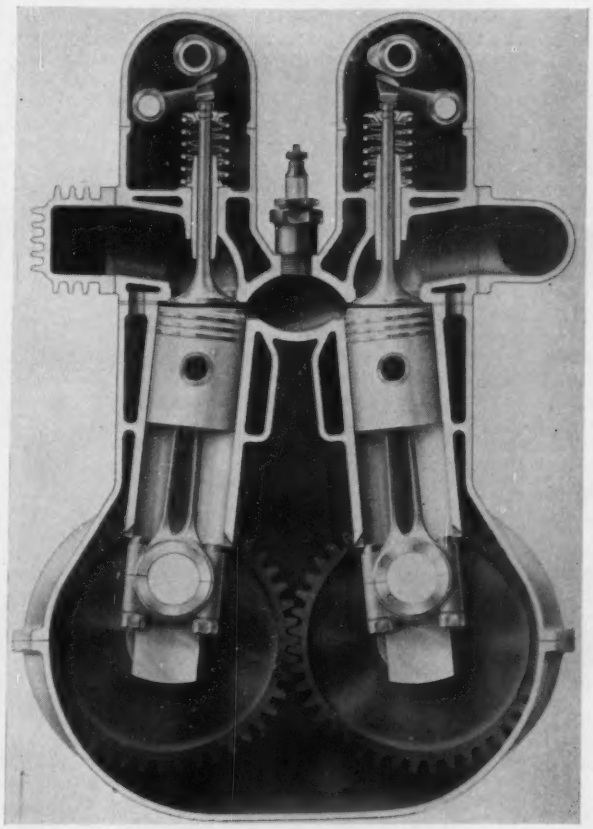
Tests show .632 cubic meter of gas was consumed, having a calorific value of 4,500 calories per cubic meter, as against .4 liter of liquid fuel rated at 8,240 calories per liter. The respective consumptions therefore are for gas, 2,850 calories, and for gasoline, 3,290 calories. The economy in favor of gas is 10 per cent. It was suggested that this advantage was due to the more perfect mixing of the gas with air to form the explosive mixture. The performance of the truck was entirely satisfactory, comparable to any gasoline-driven vehicle.

Trackless Trolleys. New interest in trackless trolleys was evidenced when eight such vehicles were shipped to Manila in the Philippine Islands.

These vehicles are a cross between a trolley and a bus; they have the body and chassis of a bus, but are driven by electric motors fed by current from an outside source, conducted to the vehicle by double overhead wires.

Two 600-volt General Electric railway motors furnish the motive power. The controls are similar to those of an electric car, except that the accelerating switches are connected to accelerator pedals. This arrangement leaves both hands of the driver free to steer.

Controllers of the series-parallel type are used. They are built to operate over a range of from 300 to 600 volts.



Courtesy Automotive Industries

SECTION, SILVANI DUAL CYLINDER ENGINE

These controllers are used to operate the contacters, which make or break the circuit for the motors. Each controller has seven positions. As a safety feature, switches are connected to the emergency brake, shutting off the current each time this brake is applied. Hand operated switches reverse the motors.

Two trolley bases and poles are provided, with swivel harps and wheels arranged to follow the two overhead wires. The poles are of sufficient length to accommodate trolley wires ranging from 16 to 22 feet above the ground. At moderate speeds the trolley can maneuver a distance of from 8 feet to 9 feet, center line of trolley to center line of wires.

A Gasoline Engine of unique design has been developed by Eugenio Silvani, of Milan, Italy. The engine has its cylinders connected in pairs, acting as one. The cylinders have a common compression chamber between them. There are two crank shafts, connected by gearing.

Large-sized valves pass a maximum quantity of gasoline and exhaust gas with a minimum lift. The combustion chamber can readily be designed to give any required volumetric compression ratio. The spark plugs are easily cooled. Rapid combustion is said to be effected, due to the turbulence of the gases as the pistons approach the top.

Vanadium as a Catalyst. Although compounds of vanadium have long been known to possess catalytic properties, their use has not been widespread on account of their slow action. Research, however, has developed certain compounds which are expected eventually to take the place of platinum in the manufacture of sulfuric acid by the contact process. They are complex silicates of vanadium, and exhibit high activity; conversions of SO_2 to SO_3 of 97 to 98 per cent have been maintained at commercial rates.

The advantages of vanadium are twofold. The cost is much less than that of the expensive platinum. Furthermore, platinum gradually decreases in activity as a result of poisoning by the small amounts of such substances as arsenic and hydrochloric acid, often met with in commercial sulfur dioxide. This naturally increases the cost. Vanadium compounds are untouched by these impurities. It has been predicted that these new catalysts will entirely displace platinum within the next ten years.

Neon Light for Aviation. Research engineers of the General Electric Company have recently developed a quartz neon gas-filled lamp which has peculiar fog-piercing properties. The lamp when being used resembles a ball of fire, since practically all the light radiation is in the lower part of the spectrum.

It has been known to pierce a dense fog at a distance of a half-mile, while on a clear night it has been seen at a distance of seventy-five miles. The red light given off is expected to aid aviators in picking it out from the ordinary white lights.

A hot cathode within the tube, which permits sufficient electron emission for the luminous discharge, allows the lamp to be operated on ordinary voltages. Former types of neon lamps required up to 15,000 volts, a voltage not only inconvenient to generate, but dangerous to handle.

Recent Books

This department conducted in co-operation with the faculty

NEW METHODS IN GEOMETRICAL OPTICS. *By* CHARLES S. HASTINGS, PH.D. *The Macmillan Co., New York, 1927, 103 pages*

The usual practice in designing an optical system is to assume specific values for the radii of curvature, the indices and dispersions of the glasses and their thicknesses and separations. A few representative rays are then traced through this tentative system. From the behavior of these rays, the designer changes the assumed values in accordance with his experience and continues the process, testing each succeeding set of values, until the residual errors are small enough to be corrected by the empirical methods of the working optician.

This method of procedure leads indirectly to the final result after many inferior systems have been computed and rejected. Frequently, it is sufficient to know only the secondary errors in a lens without computing the entire system. Thus, an astronomer might tolerate a considerable error in the focal length of his telescope but could not permit even small errors in such quantities as the color correction. By Hastings' methods, the fundamental equations are so simplified that their derivatives (which give the secondary errors) can be managed. The method consists briefly in introducing such entities as wave-surfaces, surface curvatures, and wave-velocities, in place of distances, radii and indices.

This book suggests a method of approach to the subject of geometrical optics which fits a certain type of mind particularly well. It is recommended for the advanced student of optics, both because of its broadening influence, and because it may demonstrate a method which will be more obvious to him and to which he may switch before too much contact with established methods has made it impossible or undesirable. When other methods have long been established the burden of proof is obviously on the proponent of any new method. In this sense, the present work seems inadequate. A few practical examples are given, but they fail to make clear the real saving in time and effort over the older methods.

PROFESSOR HARDY.

THERMIONIC PHENOMENA. *By* EUGENE BLOCH. *Translated by J. R. Clarke. E. P. Dutton and Co., New York City. 145 pages with 24 diagrams. Price $2.50.*

This book provides an excellent survey and summary of our present knowledge concerning the emission of electricity from hot bodies After a short historical review, the author describes the experimental arrangements usually employed in studying the phenomena. The methods available for the measurement of the temperature of the heated electrode, for attainment and measurement of the state of vacuum of the apparatus, and for the measurement of the currents are described.

The third and fourth chapters deal with the question of electron emission in a vacuum, the third from the theoretical and the fourth from the experimental standpoint. The original kinetic theory of Richardson, the later thermodynamical considerations, and other viewpoints, such as the chemical theory of emission, are considered in a thorough, yet simple manner. The experimental results are considered as a test of Richardson's law. The values of the constants in this law are considered in some detail. The thermionic emission from Wehnelt cathodes is also discussed in this section.

The fifth chapter is concerned with the distribution of velocities among the electrons and with the exchanges of energy in electronic emission both from the theoretical standpoint and also from the experimental side.

The sixth chapter is devoted to a careful and extremely readable discussion of the effect of space charge, its effect on the difficulty of obtaining saturation currents and the other causes which are also obstacles to obtaining saturation. The saturation curves are carefully analysed and resolved into their various parts.

The next chapter considers the effect of gases on electronic emission. In this part the conflict between the chemical and intrinsic theories of emission is discussed and the evidence on both sides is presented. Certain strange chemical phenomena at very low pressures are discussed.

The eighth chapter deals with the emission of positive ions by metals in a vacuum and in gases. The ninth chapter presents a survey of the emission of ions by heated salts.

The last chapter handles some of the applications of thermionic phenomena, those of the measurement of high vacua and the rectification of alternating currents.

The book is written in such a way that it can be read by one not extremely well versed in theoretical physics. It is full of suggestions for further research and the need of such is continually emphasized. It is surprising that no mention is made of the thoriated tungsten filament which has been used so extensively in radio receiving tubes. However, the book is well deserving the attention of every one interested in any field which is allied in any way with thermionic emission.

N. H. FRANK.

A GUIDE TO THE LITERATURE OF CHEMISTRY. E. J. CRANE and A. M. PATTERSON, *Editor and Former Editor of "Chemical Abstracts." John Wiley and Sons, Inc. 1927. 437 pp. Price $5.00.*

The rate at which new knowledge is being published in the fields of chemistry and chemical engineering has of late years assumed staggering proportions. The result of this increased research activity not only has affected the individual scientific journals but particularly the index publications. At least one well-known index has recently been abandoned because the flood of material was so rapid that the staff could not keep up with it. As J. F. Thorpe, the famous English chemist, puts it, "Civilization seems to be confronted with two ever growing problems — the increase in its cemeteries and its libraries."

Nevertheless, the chemist in somewhat greater degree than his associates in other sciences, is dependent upon the earlier work of others as a basis for his current progress. Unless he can locate in reference books and chemical journals the data which he needs, valuable time must be wasted in acquiring in the laboratory information which is already on file in the library. One of the qualifications which employers are now demanding of their young chemists is the ability to use efficiently the bibliographical tools which are available. It is peculiarly true in chemistry that the library work relating to a research cannot be delegated to a librarian: only the chemist himself is able to perceive the significance of various articles in relation to his own problem. Because of the vast quantity of recorded knowledge and the necessity that the chemist himself shall be able to locate the desired data, much attention is now being given to training in the best methods of searching the chemical literature.

The purpose of this review is to draw attention to an especially valuable aid of this sort. This book is written by two chemists eminently qualified for the work by their long association with *Chemical Abstracts*. In assembling their text they have drawn heavily on material which would not have been accessible to other authors and have been aided by the construction criticism of some two hundred chemical correspondents. The result of their work has been to produce a book which is entirely unique in its field and well worth to any chemist the price for which it is sold. It is not the sort of book which will be used in college and then forgotten, but on the contrary will constantly be useful in later years.

The primary purpose of the volume is to guide the chemist in locating the information he seeks. To this end the early pages are devoted to a consideration of the various types of reference books and periodicals which contain chemical information. An entire chapter is devoted to the treatment of chemical patent literature. Another is given to a particularly valuable treatment of those miscellaneous aids such as bulletins, theses, addresses and lectures, bibliographies, unpublished material, and personal correspondence, which are often overlooked or underrated by the chemical worker. Just as *Chemical Abstracts* has laid so much stress on proper indexing, so this book emphasizes the importance of this matter by a chapter which merits frequent re-reading as the hints and suggestions contained in this section are worth the price of the book.

The appendix is large but contains some very unusual features. For example a long catalogue of symbols and abbreviations used in chemical literature includes those from foreign languages and related sciences. There is a record of Canadian and American libraries which indicates the location, size, special collections, and photocopying facilities of each. Many coöperating industrial libraries are included. Another enrollment tabulates 1889 different chemical periodicals of which 1263 are still being published. This is so arranged that the official abbreviation is indicated as well as the frequency of publication, name and address of publisher, cost per copy, etc. Finally there is a list of 4229 chemical books which have been selected by the authors with the assistance of 154 experts, as being the best treatments of the respective fields. This feature is of special value when it is desired to locate an authoritative treatise in a branch of chemistry not directly familiar to the individual worker.

ERNEST H. HUNTRESS.

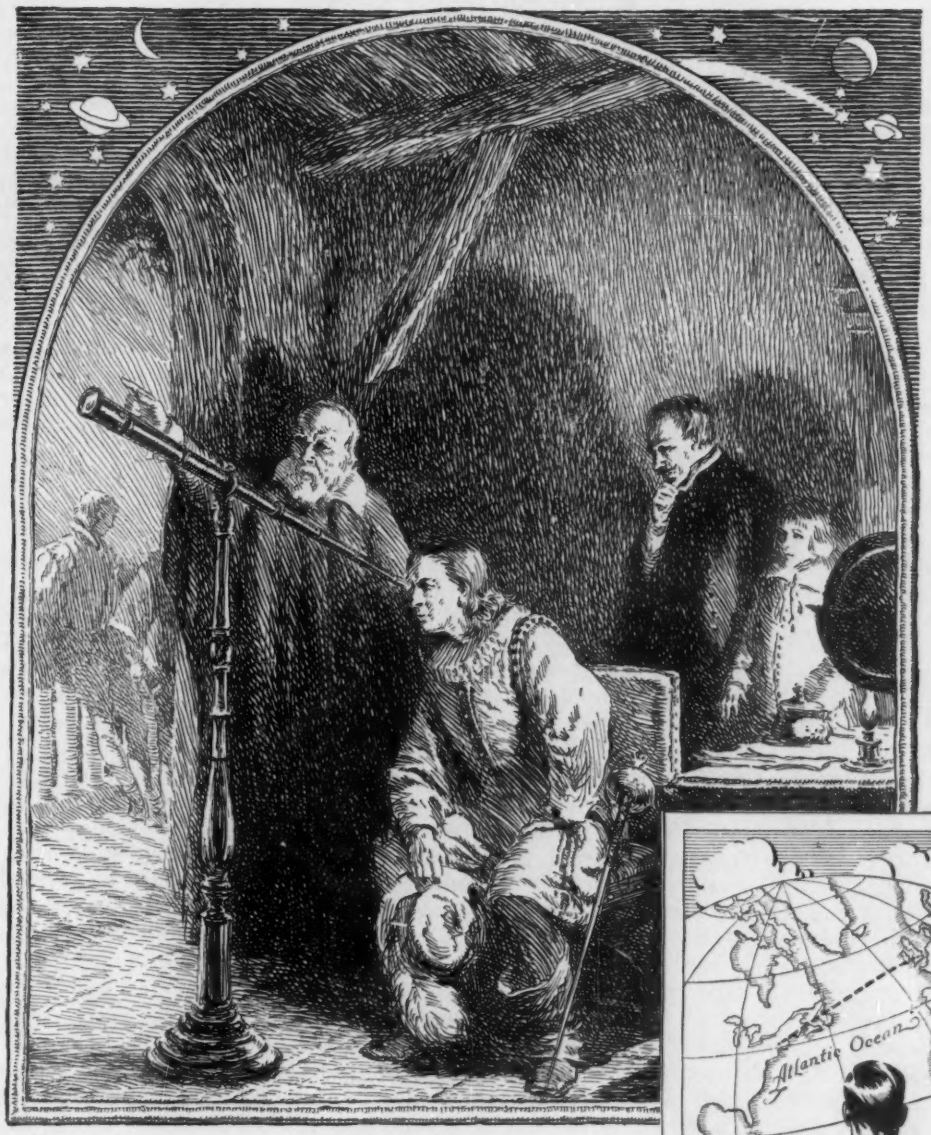
ELEMENTARY BUILDING SCIENCE. ALFRED EVERETT. *Oxford University Press, American Branch, New York City. 159 pages, illustrated. Price $2.50.*

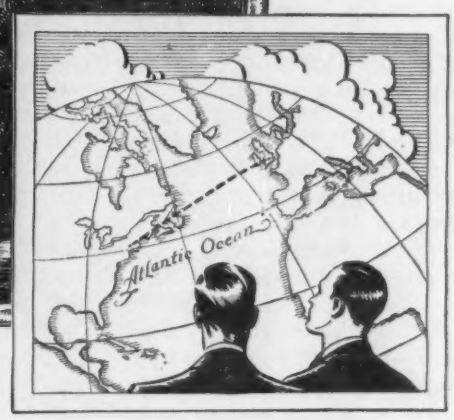
In spite of a preface apologizing for the title used, it is more than one can understand how this book came to be called "Elementary Building Science." It treats of everything in elementary science from how to measure in the metric system, to glass blowing, and why a barometer falls before a storm. Except for but one chapter on rocks, iron, lead, etc., there is nary a mention of anything concerning buildings.

It would be a very excellent book as an introduction to General Science in high schools. Everything is explained in a reasonable, common sense way, logical steps supplanting mathematical analysis.

Very clear diagrams are given, showing how various types of pumps, siphons, scales, etc., work. The realm of chemistry is introduced with a chapter on chemical principles, elementary hypotheses and basic laws. Oxygen, hydrogen and their action are explained, followed by a chapter on hard and soft water. Each chapter has at its close a list of simple exercises to be performed.

With due exception for some of our Freshmen, we are afraid we shall have to admit that most Massachusetts Institute of Technology men have progressed beyond the stages of science covered by this book.





Telephone men of today are extending the horizons of speech to points beyond the seas.

New Worlds for Old

LIKE Galileo, every pioneer seeks new worlds. In the telephone industry this has led to discoveries of ways and means to better service.

Telephone pioneers of yesterday hewed a way through intricacies of science, finance and business management to establish the era of "distance speech."

Telephone pioneers of our own day *imagined* a 'cross-ocean service—and then made it.

Telephone pioneers of tomorrow will face the challenge of new and greater problems sure to arise.

BELL SYSTEM

A nation-wide system of 18,500,000 *inter-connecting telephones*

"OUR PIONEERING WORK HAS JUST BEGUN"

Compounding

(*Continued from page 89*)

product, with its several phases, is like a piece of granite whose excellent properties are dependent upon the properties of the several minerals that go to make it up, and upon the way in which these minerals are put together to constitute the mass of granite as a whole.

Strange as it may seem, in view of the much advertised and boasted advances of science and its all-seeing and all-penetrating eye, there is today no scientist who can define any really fundamental physical laws respecting the effect upon the ultimate physical properties of the final product when compounding together even the simplest and best known compounding agents. By this I mean no such law as fundamental as is Newton's law of gravitation to the understanding of motion, or even anything as fundamental as the laws by which a structural engineer determines the weight sustaining capacity of a steel building. The laws for the design of steel buildings are reasonably well worked out and almost universally accepted. An engineer can design a ten-story building to sustain a very heavy load on any given floor, and he will design this building, using certain fundamental rules and certain methods of putting together the individual steel members which constitute the structure as a whole. If, on the other hand, a compounder is asked to furnish a rubber block which will sustain a certain load with a given deflection, he will not by any given set of rules produce a block of rubber which will give this result. Similarly, if a rayon or synthetic thread designer is asked to give a thread of a certain elongation, certain resiliency, and certain ultimate strength, he, too, is unlike the civil engineer in his approach to the end in view. The compounder has certain generalities which will guide him in judging the compound, but he is no more in a position to tell you, with any kind of mathematical certainty, what the ingredients and properties of the compound will ultimately be after many cuts and trys, than are the aboriginal designers of the very excellent twisted fiber rope bridges that they build so successfully with no comprehension of the laws of load distribution able to discuss the underlying theory of their structures.

We have no fundamental underlying law in the compounding art rationalizing such an elemental thing as the production of a plastic or clay-like body when almost any very finely divided solid is incorporated into water or oil or any other fluid. We do not even have any sort of reasonably agreed upon visualization or picture of the structure of this two-phase system. Many of those who would perhaps be expected to have real information on this subject, talk loosely about colloids and colloid phenomena. When pressed for information that might lead to assistance in the designing of compounds, their colloidal phenomena explanations lead the compounder nowhere but into a maze of speculation based on little fact.

When asked why it is that there is no fundamental law or even visualization of what might be termed this first step in the compounding art, the answer lies largely in the fact that it is very easy to observe and study structures or assemblies made up of beams, elements or members that can be measured in terms of inches and feet, but when it comes to dealing with individual units of the order of magnitude of 1 micron (1/25,000 of an inch) or less, the problem is out of the range of the ordinary mind's experience. It requires a much more highly trained and refined technique to even visualize and appreciate such magnitude.

Moreover, instead of a few hundred or a few thousand structural pieces to make up an assembly, a few thousand bricks to make a brick wall, for example, we have billions and quadrillions of particles to deal with. To make a bucket of paint which, when applied to a surface, will harden into a film with a certain resistance to marring and rubbing, and with a certain capacity to elongate and contract as the wood upon which it is applied elongates and contracts, we start off with a liquid, such as linseed oil, or nitrocellulose solution, and mix into that bucket of paint millions and quadrillions of particles of zinc oxide. This compound, the paint film, consisting of a suspension of zinc oxide in hardened linseed oil, has no physical or engineering basis of design. It has been arrived at purely and simply by the cut and try process. Only within the last five years have physical stress and strain tests even been attempted upon so important an engineering material as a piece of paint film.

I could go on at much greater length pointing out our failings as scientific compounders, and this pointing out might have some value in stimulating concentrated research on some of the simplest phenomena. For the present, however, I would turn and emphasize one hopeful direction in which we may look for great help in the future.

If metallography is the study of the structure of metals, and is an attempt to correlate their physical properties with the size, shape, number and graphical distribution of the several phases, crystalline and non-crystalline, which go to make up a piece of metal, is not plastography a still broader name and a still broader field for the study by this same procedure of all plastics of which metals are but one class?

The structure of metals becomes visible under the microscope at relatively low magnification, is fairly easily developed by etching agencies, and is also visible by reflected light. On the other hand, most of the plastics, such as rubber, varnish, paint, nitrocellulose, rayon, bakelite, etc., are structures which require the highest powers of the microscope or X-ray spectrograph to reveal their several phases and graphical distribution. These latter materials are not easily and simply etched or stained to differentiate the several phases, and furthermore, they almost always have to be examined by transmitted light, *i.e.*, in micro-section an art in itself to produce, rather than by reflected light, as in the case of metals.

Some progress has been made in the plastic field by applications of this method, notably in rubber, but almost nothing has been accomplished in the other fields. The harvest that lies ahead is probably greater by far than that which has been realized by the application of structural study or metallography to metals.

I would make a strong appeal for a chair in every technical school devoted to the compounding art. As the first assignment of work for that department, I would designate the development of the art and science of the plastographer. It is an art that cannot be mastered easily; it requires years of training in order to use high power microscopical equipment and to intelligently interpret what one sees, but there is a great scientific goal to be reached and much benefit to mankind to be achieved. Not the least of the blessings to be conferred upon the pioneer in this field will be those most gratefully acknowledged by the vast army of truly humble compounders, for the most part graduate physicists and chemists, who are still struggling, with little order visible in a vast chaos of unknown fact, to solve their problems with an almost hopeless number of cuts and trys.

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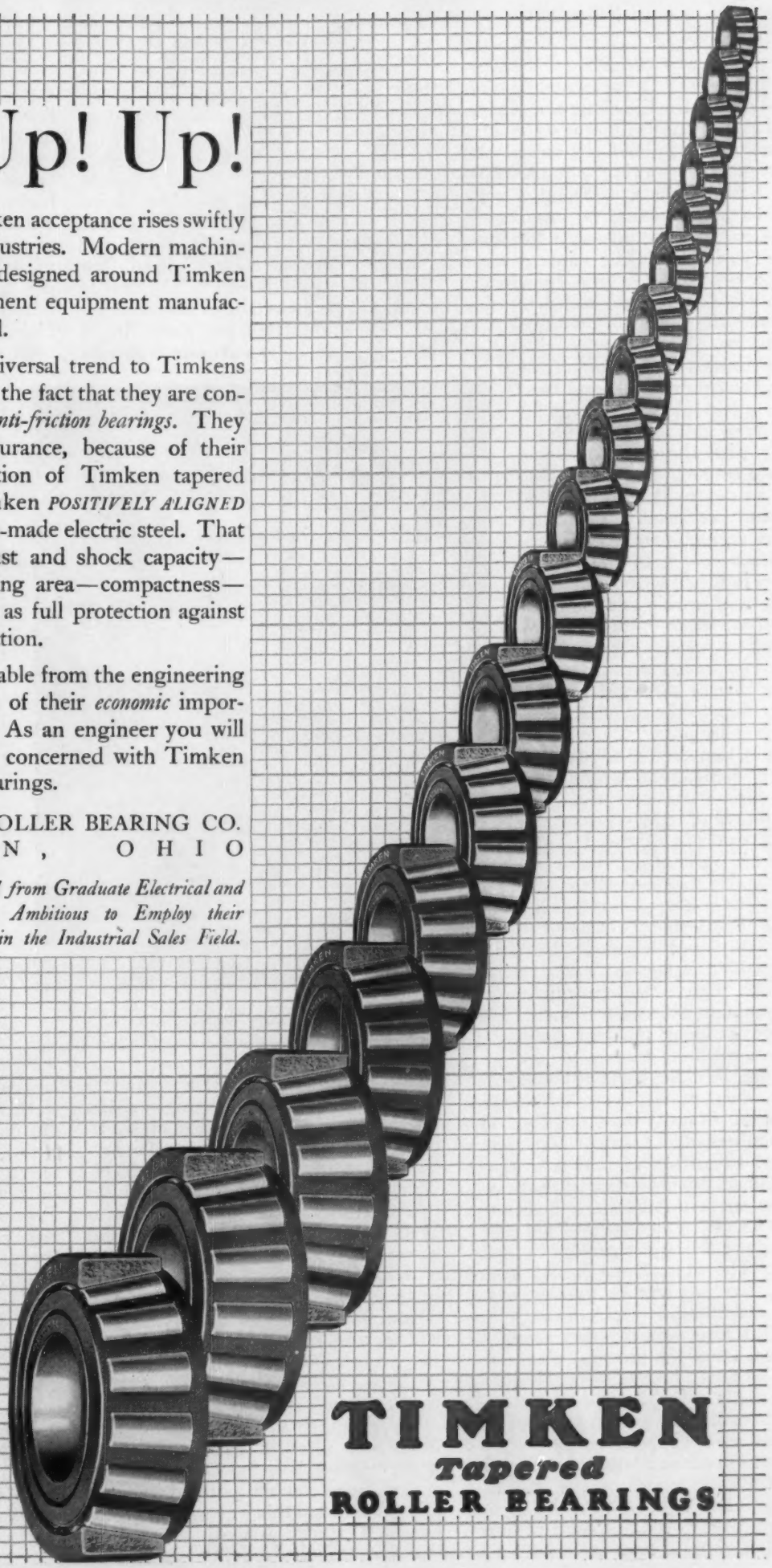

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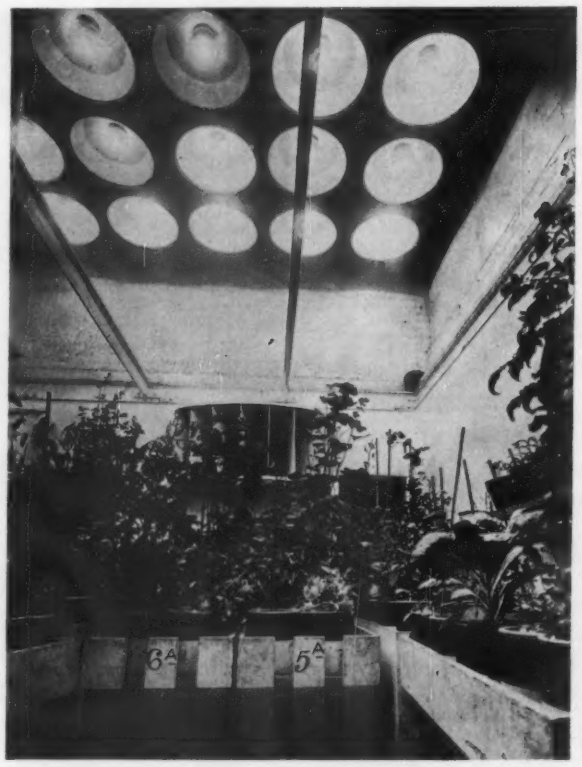
Plant Research

(*Continued from page 92*)

climate where all factors could be controlled during the life history of plants, and then vary one or more factors in a definite direction and determine the result on the growing plants. This must be done on a sufficiently large scale to accommodate a number of plants so as to compensate for individual variations. The climate must also be controlled over a sufficiently large time interval to determine whether the effects produced are cumulative. After some consideration it was decided that a few of the natural environmental conditions which affect plants can not be reproduced and maintained artificially with the apparatus now available. Such factors as sunlight are extremely difficult to reproduce artificially. Sunlight even in nature is not a constant. It varies from 0 to 10,000 foot candles in illumination value and in length of working day for the plant from near 0 to 24 hours. In quality it varies from a light source rich in red with little blue to one rich in blue and in ultra violet, even to the point of possible injury to plants. There was a question, therefore, as to just how far one should go in reproducing all of these variations in an artificial source of light. Garner and Allard, working in the Department of Agriculture, have already shown that some plants are attuned to flower on certain day lengths. Plants may be attuned to other daily and seasonal variations of light either of quality or intensity. If we consider sunlight at its maximum intensity, at noon in June, as being the ideal light source for plant growth, we at once face the difficulty of producing and maintaining an artificial light source similar in intensity and quality. The common gas filled filament lamp has a distinct advantage in that it is easily maintained. Its chief disadvantage as a light source is its low color temperature, which results in an excess of red and a shortage of the blue regions of the spectrum. The white flame carbon arc of twenty-five amperes or greater has a color distribution which closely approaches June sunlight and would be an ideal lamp for growing plants if it could be easily maintained. The life of the carbons in this type of lamp is only a few hours burning as an open arc. If enclosed in a glass globe to increase carbon life, cerium or other metallic salts from the core deposit on the glass and decrease the light output by about fifty per cent in the first hour of burning. It is hoped that at some future time a light source can be devised which will eliminate some of these difficulties.

For the present studies several different light sources were used in two sets of artificial climates, and the equipment as now installed at the Boyce Thompson Institute consists of the "Gantry Crane Houses" and the "Constant Light Room." The first is a set of two greenhouses about 25 by 30 feet illuminated at night by a battery of 48 1,000-watt lamps carried on a Gantry crane. The crane is electrically driven and is run over the house at night for a period of six to twelve hours and off again in the daytime so as to avoid shading. Temperature is controlled in these houses by electrically operated solenoids actuating steam valves on the general steam supply lines. Carbon dioxide is delivered to the houses through a system of meters and pipes from steel drums, an arrangement very similar to that used in carbonating beverages. Since quite an appreciable quantity of the gas is necessary for these experiments, about six 50-pound drums per 24-hour day, an arrangement has been developed recently at the Institute whereby flue gases from the combustion of hard coal can be purified and the CO_2 produced in this way used in greenhouses. This utilizes waste gases and at the same time gets rid of the smoke nuisance. CO_2 concentration in the greenhouses was kept at about .3 per cent or ten times the normal amount. This concentration is comparatively easy to maintain in winter when the greenhouse ventilators can be kept closed, but much more difficult to maintain on warm spring days when the ventilators must be open to maintain temperature. No attempt was made to control humidity in the greenhouses where higher concentrations of CO_2 were used. Humidity was controlled in the "control greenhouse" where no additional light or gas was given. This was accomplished by means of standard air conditioning machinery. The air from the greenhouse was recirculated through a system of metal ducts to a spray tank in the basement and returned again through a bank of heater coils. By controlling accurately the saturation temperature in the spray tank and raising the air to room temperature as it passed through the heating coils any desired degree of relative humidity can be maintained in the house provided the volume and rate of air movement is adequate.



THE "CONSTANT LIGHT" ROOM
A glass-water filter is placed between the light and plants

The second set of controlled conditions was the "Constant Light Room" and a dark room adjoining it. These rooms were each about eleven feet square. Temperature, humidity and carbon dioxide supply were controlled in these rooms. The air conditioning was accomplished by standard air conditioning apparatus similar to that used in the control green house already described. The light room was illuminated solely by artificial light. In one series of experiments 25 1,500-watt lamps were used continuously during the entire growth-period of the plants. These were mounted in the ceiling of the room and equipped with suitable reflectors to direct the light downward. In another series of experiments an effort was made to increase the blue region of the light source by adding 325-ampere white flame carbon arcs to a bank of 22 1,500-watt filament lamps. An infra red filter composed of a plate of glass over which water was continuously circulated was interposed between the lamps and the soil in which the plants were growing. A large volume of air was driven continuously through the space over the glass plate, and around the lamps, to remove the excess heat.

Plants were exposed continuously in the light room during their entire

(*Continued on page 126*)

Quality

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MISSISSIPPI

Titanium

(*Continued from page 93*)

Titaniferous Hematites

Known deposits consisting of combinations of hematite and ilmenite are very extensive. Probably the largest of these known deposits are located in Norway, although there are several bodies of ore of considerable size in Canada, notably those at Baie St. Paul, and also at Ivry, Province of Quebec. These deposits usually carry from 35 to 40 per cent titanic oxide and from 50 to 55 per cent iron oxide.

Separation of the hematite and ilmenite cannot, however, be made by magnetic means as the ilmenite is almost as magnetic as the hematite, and the ores in their native state are too high in titanium and too low in iron for use in the blast furnace as a source of iron. It is apparent, therefore, that in all probability these combinations of hematite and ilmenite will not be as attractive ores from the economic standpoint as the magnetite-ilmenite ores.

Deposits of Beach Sand Containing Ilmenite, Zircon, Monazite and Rutile

Deposits of this character occur in a number of tropical and semi-tropical localities. So far as present knowledge is concerned they are not believed to be nearly as large as the magnetite-ilmenite or hematite-ilmenite deposits already referred to. The sources of these ores are not definitely known, but in most cases it seems to be apparent that they are caused by erosion, the heavy sand being carried by river or sea water and subsequently deposited on beaches or river bottoms.

A number of these deposits were originally worked as a source of monazite, a mineral used quite extensively in the manufacture of gas mantles, because of its content of thorium. Until recently the operators of these deposits had practically no market for their ilmenite, zircon, or rutile and these minerals were accumulated and it is only within the past few years that the operators have been able to sell their ilmenite and comparatively small tonnages of zircon and rutile.

The deposit operated by The Titanium Pigment Company, Inc., located on the east coast of Florida just north of St. Augustine, has probably operated more steadily and produced larger tonnages of these minerals during the last ten years than any other deposit of this type. Here the mineral sands are deposited by wave action on a strip of beach about fifteen miles long. Although the beach is approximately five hundred feet wide, the concentration of the heavy minerals occurs to a width of about one hundred feet at the base of the dunes, the vein varying from a few inches to several feet in depth. The method of operation is to scrape the beach, convey the sand to a concentrating mill, where it is first run over Wilfley or Diester tables to remove the quartz and other light minerals. The heavy concentrates from this table separation are then passed over magnets, which remove the ilmenite, after which the zircon, rutile and monazite are separated by further tabling, and finally by passing over Huff electrostatic machines.

It is apparent that deposits of this type necessitate in the first place a balanced market for the several minerals produced, and secondly, that on account of the low concentration of the mineralized sand on the beaches the amount of material to be handled and the excessive distance over which it has to be hauled, make the operation expensive for each ton of the heavy minerals produced. There is little chance, therefore, that deposits of this character will ever furnish a particularly cheap source of titanium.

Rutile

The two best known rutile deposits are those of the American Rutile Company, at Rosalind, Virginia, and one located at Kragerö, Norway. These are both massive deposits, the rutile occurring in combination with ilmenite. Because of the low percentage of rutile carried in these ores it is necessary to handle many tons of ore for each ton of rutile concentrates produced and, for this reason rutile is more cheaply produced at the present time from the beach sand deposits referred to just previously.

The quality of rutile from these two sources is very similar and runs approximately 94 per cent titanium oxide in the rutile concentrates.

Development

The earliest work, of which we have record, with titanium was the use of titaniferous magnetites and in some cases so-called titaniferous hematite as sources of iron in blast furnace practice. There is record of operations of this kind being carried on in Great Britain, Norway, Canada, and the United States as early as the middle part of the last century. It is interesting to note that in all of these early operations ores containing as low as from 35 per cent to 45 per cent metallic iron were used. These were crude titaniferous ores carrying high percentages of titanium oxide and other impurities so far as blast furnace practice is concerned. In view of the low iron content and the high percentage of impurities it is not surprising that none of these early efforts to utilize titaniferous iron ores in the blast furnace was successful. Very briefly the history of the blast furnace operation in Essex County, New York, on the property that is now owned by the MacIntyre Iron Company was as follows:

In 1840 a small charcoal furnace was erected at a little village called Adirondack, approximately thirty miles west of Lake Champlain. Titaniferous iron ore carrying approximately 45 per cent iron and 20 per cent titanic oxide was used exclusively; the limestone supply came from a nearby point. This furnace was remodeled in 1848, and in 1852 a much larger furnace (11′ 6″ x 48′) was built and operated successfully for three or four years.

The iron made in this furnace was of excellent quality and was awarded a prize at a national exposition held in Jersey City during that period. That a furnace so located could not long compete commercially is indicated by the fact that pig iron as made was first transported by barges down the Hudson River, a distance of approximately ten miles, and from that point loaded on to horse-drawn sleds during the winter and hauled thirty miles to Lake Champlain, where it was loaded on barges for shipment to the iron foundry in Jersey City, where it was used.

This old furnace, still standing, in fairly good state of preservation, was recently carefully examined by experts. Their report to the present owners of the property was conclusive that no serious difficulties had been encountered in the smelting of these crude titaniferous iron ores. The lining shows no sign of scaffolding; the hearth was blown out clear to the bottom, and the slags show evidence of considerable fluidity.

As years rolled by there grew up a prejudice against the use of titaniferous ores in blast furnace practice. About 1890, the late Dr. Auguste J. Rossi, whose name has since become well known because of his work on titanium, was engaged to demonstrate that titaniferous iron ores could be successfully used in blast furnace practice under modern conditions. Dr. Rossi built and operated a small experimental furnace at Buffalo, New York, where he succeeded in using titaniferous iron ores successfully. The reports of this work of Dr. Rossi were pub-

(*Continued on page 112*)

Blasting
for Excavation Work

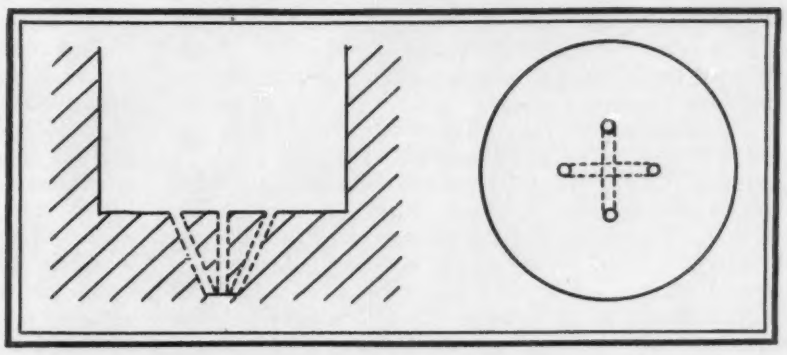

Diagram of loading a cut shot in a well

LESSON NO. 9 FROM

THE BLASTERS' HANDBOOK

WHEN the steam shovel suddenly strikes a stratum of heavy clay, hardpan, or shale, how can explosives be used to keep the yardage up to schedule? When the excavation is for a foundation how can you use explosives without weakening the support for the building? In blasting foundations through rock, how should dynamite be used to avoid cracking the rock beyond a certain line? How should bore holes be loaded, how placed?

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TE-4

Titanium

(*Continued from page 110*)

lished in the technical papers of the period.

Ferro-Titanium

In connection with his researches concerning the use of titaniferous iron ores in the blast furnace Dr. Rossi produced an alloy of iron and titanium, which proved to be a most efficient deoxidizer and cleanser for the treatment of steel because of the great affinity of titanium for both oxygen and nitrogen, and also because of the property of titanic oxide formed by the oxidation of titanium of combining with other slags and oxides and increasing their fluidity, thus effecting their release from the steel by causing the combined oxides to rise to its surface and combine with the slag.

From this early work of Dr. Rossi's there were gradually developed two types of ferro-titanium, which are in general use today, the cheaper and more extensively used being the product produced in the electric furnace by reduction of titaniferous ores with carbon. This product is now generally sold under the trade name of "Ferro Carbon-Titanium," the more expensive and lesser used alloy being that produced by reduction of titaniferous ores by aluminum, either by the Bath process of Dr. Rossi, or the Thermit process of Dr. Goldschmidt. This aluminum reduced ferro-titanium is sold under the name of "carbon free" or "free from carbon ferro-titanium."

The addition of both types of ferro-titanium is made in the steel ladle as the steel flows from the furnace, and it is usually the last addition made in the ladle. It is essential that the entire addition of titanium be made before the slag begins to flow from the furnace, so that the action of the titanium may take place in the steel and not be wasted in the slag. In order that the action of titanium may be completed it is necessary to hold the steel in the ladle for several minutes after the last of the titanium has been added.

A great many references to the use of ferro-titanium in connection with different grades of steel are to be found in technical literature.

Titanium Pigments

The most important development in connection with the commercial use of titanium has resulted from the research work carried on in this country by L. E. Barton and Dr. Rossi, and in Norway by Dr. Jebsen and his associates, in connection with the use of titanium oxide as a white pigment for paint and other purposes. This work was begun in the early years of the present century, but it was not until 1917 that the first commercial plant for the production of Titanium Pigments was built.

The process for the manufacture of Titanium Pigments most generally used consists of dissolving finely ground ilmenite concentrate in sulphuric acid, from which solution the titanium is precipitated in the form of metatitanic acid, leaving the impurities dissolved in the solution. This metatitanic acid is dried, calcined and finely ground to produce titanium oxide. Titanium Pigments are marketed in three forms at the present time, the most widely used being a composite pigment known as Titanox, in which titanium oxide is intimately mixed and coalesced with a blanc fixe base; a second composite pigment consisting of titanium oxide and calcium sulphate. The composite pigments are made by precipitating the metatitanic acid in the presence of the blanc fixe or calcium sulphate base, producing intimate mixtures of the

(*Continued on page 114*)

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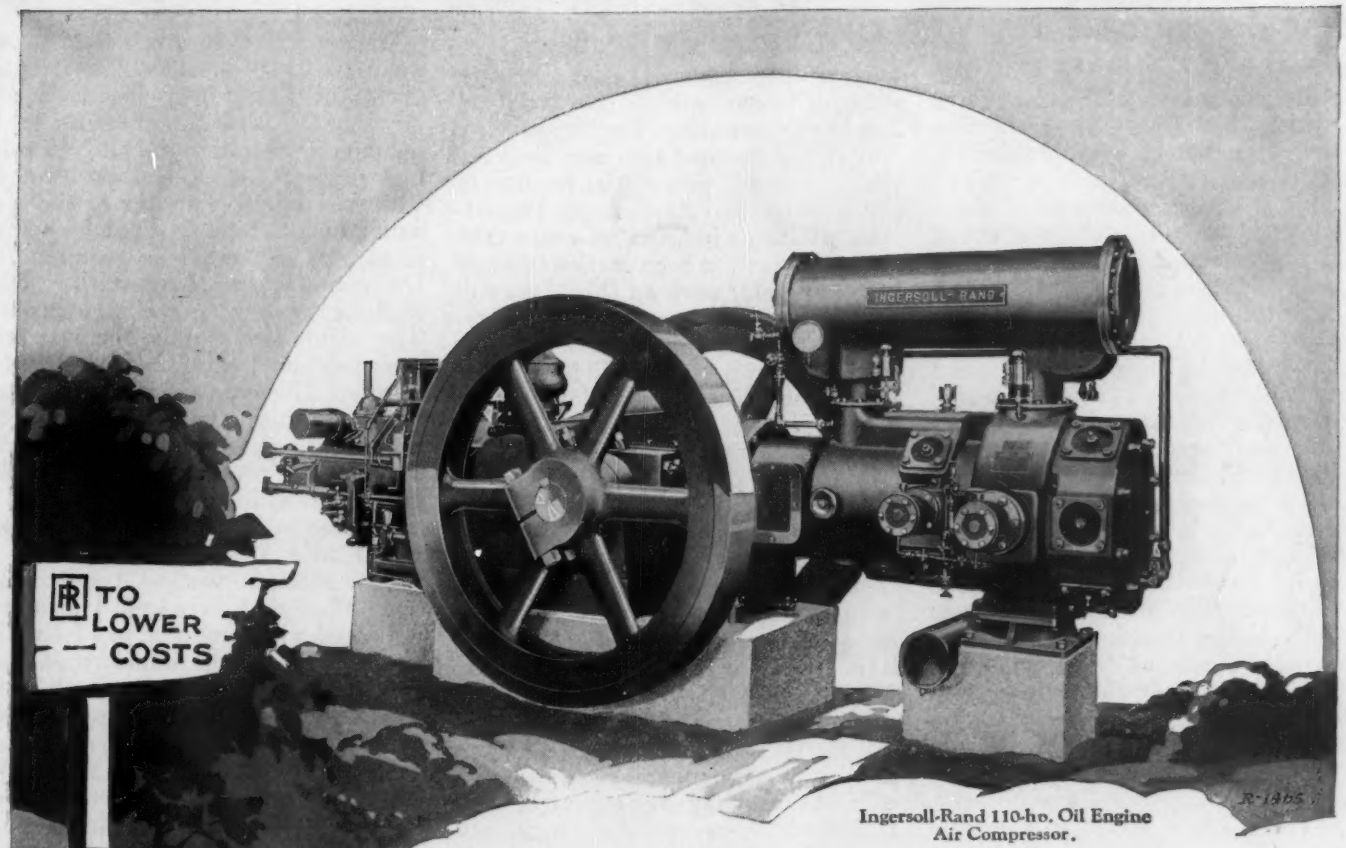

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Titanium

(*Continued from page 112*)

two materials, particularly after the calcining and milling. The third form in which Titanium Pigments are marketed is that of a pure titanium oxide. Pure titanium oxide is a white pigment with many interesting characteristics. It has excellent color, good working and brushing qualities in paint mixtures, is inert and does not react with other pigments, or with paint or varnish vehicles, and it has a much greater hiding power than any other white pigment. This great hiding power is its most valuable characteristic and largely accounts for the rapid growth in the use of various titanium pigments during the few years that they have been on the market.

In the composite pigments the opaquing power of the titanium oxide per unit of that oxide contained is actually higher than in the pure titanium oxide, and as these composite pigments can be manufactured and sold very much cheaper than the pure oxide, these composite pigments are more generally sold than the more expensive oxide of maximum property.

Titanium oxide added in the form of rutile has been used to some extent in the manufacture of arc light pencils. In the ceramic industries limited amounts of rutile are used in various ceramic bodies.

The Future

In all probability titanium will find its widest field in the pigment industry, where its use is already an important factor, as it is reasonable to suppose that as time goes on means will be found to manufacture titanium pigments more cheaply, so that in the not distant future pigments of this type will be available at costs that will compare favorably with those of the lead and zinc pigments now more generally used. The enormous sources of titanium available and the already demonstrated superior qualities of titanium pigments are a challenge to manufacturers of these pigments to see to it that such pigments are made available at moderate costs.

M. I. T. Gliders

(*Continued from page 100*)

of Mr. J. M. Shoemaker, a graduate student formerly with the National Advisory Committee for Aeronautics.

A design competition was held for the "contest" glider, the faculty of the Aeronautical Engineering Department acting as judges. As soon as the chosen design has been carried through to completion, work on this plane will begin, probably about the end of April. This plane will probably have a greater span than the first, and will have a well streamlined fuselage, following the general lines of the common airplane. About $300 will be needed for these two planes, part of which has now been subscribed.

It is understood that some of the more prominent of the present-day German gliders and their pilots are being brought to this country in the hope of fostering the art of gliding, and it is hoped to hold a gliding meet, which will give American aeronautical engineers a chance to show what they can do in this peculiar field of aeronautics. As gliders are cheap to build, competition may be expected, and with the past experience of the Society available through its files, as a background for the present work, some measure of success may be expected with these new third and fourth gliders of the Aeronautical Engineering Society.

Chemical Warfare

(*Continued from page 91*)

pating the liquid gases into the atmosphere. Siphons and pipettes are used, and generally the filling is done at low temperatures. The whole system must be free from leaks and the nozzles must not drip. Methods for filtering and exhausting fumes are required. After a shell has been filled, it must be closed and remain tight under temperature variations of from 25 degrees to 125 degrees Fahrenheit. Pipe threads have been used for closing with cement. Lately a pressfit joint requiring no threads has been developed which is satisfactory.

During the past war mustard gas was made by the so-called "Levinstein" or "sulfur chloride" process developed by the British. Sulfur chloride is manufactured from sulfur and chlorine, and presents no special problem in Chemical Engineering due to the ease with which the material can be manufactured. The ethylene required for the manufacture of mustard gas is manufactured by cracking alcohol. The plant used during the war was designed and built for the particular purpose. There was no industrial plant located in this country which could be used as a basis for a design. Briefly outlined, the process for preparing the ethylene is as follows: Ethyl alcohol is volatilized in vaporizers and the vapor mixed with steam. This mixture is passed through vertical tubular furnaces filled with vermicelli kaolin and is heated with producer gas from the outside. Under the influence of heat and in the presence of the kaolin, the alcohol breaks up to form ethylene and water vapor. The gases are passed through a separator to free them from clay dust from the furnaces and then the water vapors are separated out. The ethylene receives a further purification by being scrubbed with water in scrubbing towers. It is then passed to water sealed gas holders until used in the production of mustard gas.

The mustard gas is manufactured by the reaction between ethylene and sulfur chloride, the ethylene gas being led into the reactor containing the sulfur chloride. After the operation of the plant is started, a certain fixed quantity of mustard oil called the priming charge is allowed to remain in the reactor from the previous run. To this is added sulfur monochloride; then the ethylene gas is passed into the reactor. The reaction is carried out at a temperature from 30 to 35 degrees Centigrade. Vigorous agitation and thorough cooling are required. If the temperature is not properly controlled, the sulfur formed in the reaction comes out of solution, clogs up the pipe lines, and causes a great deal of trouble.

The last plant built at Edgewood Arsenal for the manufacture of mustard by the Levinstein process contains all the safety provisions that are known, as a result of previous experience. It must be said, however, that during the war a large number of casualties were obtained in the manufacture of mustard by this process, especially before the correct temperature control of the reaction was worked out on a plant scale. During the war this process was the only feasible one for use by this country.

(*Continued on page 116*)

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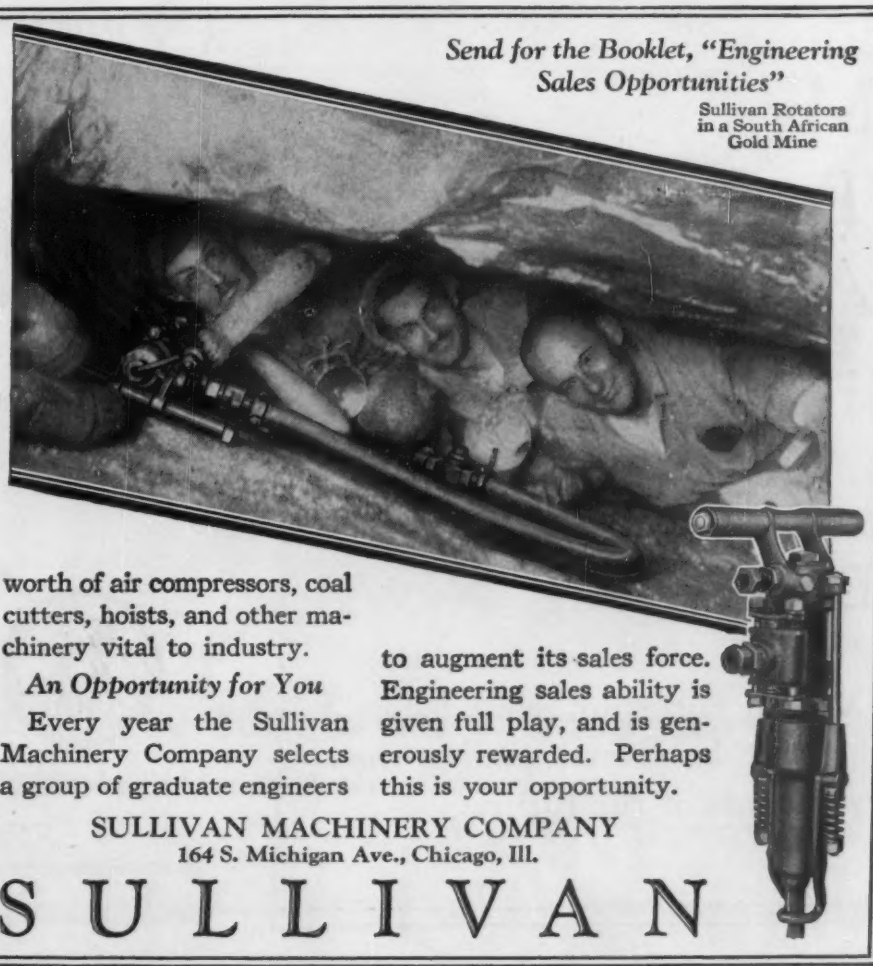

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SULLIVAN

Chemical Warfare

(*Continued from page 114*)

since it lends itself to rapid large scale production, in that a plant that would manufacture mustard could be fairly readily constructed, in spite of the fact that the equipment used is special equipment.

In addition to the objection of casualties in the operation of the plant, the Levinstein process for producing mustard is also open to the objection that the mustard procured contains approximately 20 per cent of inert sulfur which is to be eventually loaded into the shell, transported to the Front, and fired at the enemy.

During the war the Germans used what is known as the chlorhydrin or thiodiglycol process for the manufacture of mustard, which process produces a mustard of high purity. It is also understood that the Germans had few casualties in the manufacture of mustard gas. This process was more logical for the Germans, since certain intermediates were already in production in Germany, and since they had a large amount of chemical equipment more or less standard which could be used in the operations.

Since the war the manufacture of ethylene chlorhydrin on a large scale has been developed by one of the commercial concerns of this country, and the Chemical Warfare Service is, therefore, at present interested in the manufacture of mustard gas by this process.

Briefly stated, the process consists of treating ethylene chlorhydrin with sodium sulfide to form thiodiglycol, purifying the thiodiglycol, and causing it to react with hydrochloric acid to form mustard gas. Up to and including the preparation of the thiodiglycol used in the last reaction standard equipment is used. Standard equipment cannot, however, be used in the last step of this reaction, that is, the chlorination of thiodiglycol by means of hydrochloric acid.

It is desired to use a continuous process of chlorination wherein thiodiglycol is allowed to flow into the top of a tower, meeting as it descends an ascending stream of hydrochloric acid gas, so that mustard gas and hydrochloric acid solution will then be drawn off at the bottom of the tower.

Considering only the corrosive action of the material used, this reaction could probably best be handled in acid-proof stoneware. Acid-proof stoneware, however, has a tendency to crack and become slightly porous when subjected to prolonged use at higher temperatures and continued changes in temperature. If only corrosive materials such as hydrochloric acid were being handled, this would not be considered a serious objection, but since one of the products of the reaction is mustard gas, the use of stoneware is not at present considered safe. For this reason, and because hydrochloric acid of fairly high concentration must be handled at a temperature of about 80 degrees Centigrade, a special design of glass-lined steel tower will be tried for the chlorination of mustard gas.

The final choice of apparatus must also consider what materials can be used satisfactorily for gaskets and seals in the construction of the tower and other apparatus. Asphalt and rubber resist hydrochloric acid satisfactorily from a practical standpoint, but both of these materials are excellent solvents for mustard and cannot, therefore, be used. Conversely, it may be said that mustard is an excellent solvent for rubber. Lead and asbestos gaskets are about the only kind of

(*Continued on page 118*)

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materials that have been found satisfactory when used with both hydrochloric acid and mustard, and, of course, these materials are none too satisfactory on purely mechanical grounds.

Some of the advantages of the chlorhydrin or thiodiglycol process for the manufacture of mustard gas are:

1. Elimination of casualties in the manufacture of this agent.
2. Manufacture of an almost pure mustard gas.
3. The ability to use standard equipment in all except the last reaction.

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Chemical Warfare

(*Continued from page 116*)

4. The fact that all except the last reaction may be carried out by industrial concerns and harmless thiodiglycol shipped to a central point to be chlorinated by the Chemical Warfare Service.
5. The elimination of trouble with shell filling equipment due to its becoming clogged by separation of sulfur from impure mustard gas.

A point that might be mentioned, which enters into a numberof processes, is the fact that many of the compounds used in the manufacture of chemical warfare agents, as well as certain of the agents themselves, are decomposed by coming in contact with water. This makes it necessary to exercise all precautions to see that water and water vapors are excluded in the various steps of manufacture. For example, we must remove all moisture from the compressed air used in blow cases for transferring liquids from one part of the plant to another. This is usually accomplished by special scrubbing systems which employ concentrated sulfuric acid as the dehydrating agent.

Research, constant and untiring, is the daily requirement for the Chemical Warfare Service. It is our responsibility to assure the chemical defense of the nation. Our small force of regular and reserve officers and civilians is the only insurance America has against chemical attack.

We must guard against the chance that some potential enemy may discover an agent against which we have developed no protection. The only way we can do this is to investigate every possibility ourselves, to follow up every lead, to keep everlastingly at our research. Surprise is the thing to avoid. Give us time and we can develop protection, but set this down as certain — if a new agent is developed it will be done in secret and it will not be used until there is assurance that its full power can be realized.

A new chemical agent will never be used again on a small scale. As Col. J. F. C. Fuller, Senior Instructor of the British Army Staff College, Camberly, England, says in his "Reformation of War":

"In war, audacity is nearly always right and gambling is nearly always wrong, and the worst form of gambling in war is gambling with small stakes."

To use a new gas on a small scale is so senseless a gamble that we can be certain it will not be done in the future. To use a new gas on a grand scale at the proper time is not a gamble at all; it is a sure thing. It is against such a chance that our research is directed. The war of the future will find gas used to a far greater extent than it ever was in the World War. It will be employed in cylinders, distilled from candles, showered from airplanes and fired from guns. Gas operations will not be special operations. They will be the rule if effectiveness is the criterion by which commanders of the future will judge their weapons.

"Scientists are making," says General Hartley, "very rapid advances, and many of these will have a direct bearing on the next war. It is absolutely essential to make adequate provision to continue research on gas warfare problems, as otherwise all preparations for defence may prove valueless. . . . Such research can only be made effective by the closest sympathy and coöperation between soldiers and scientists, and unless their coöperation is much closer than it was before the late war, there will be little chance of success. It is for the scientists to explore the possibilities and to develop such as are thought likely to be of value, and for the soldiers to apply the results of their investigation of war problems."

Science goes ever forward. The military mind must keep pace with scientific knowledge and apply it intelligently to the study of war.

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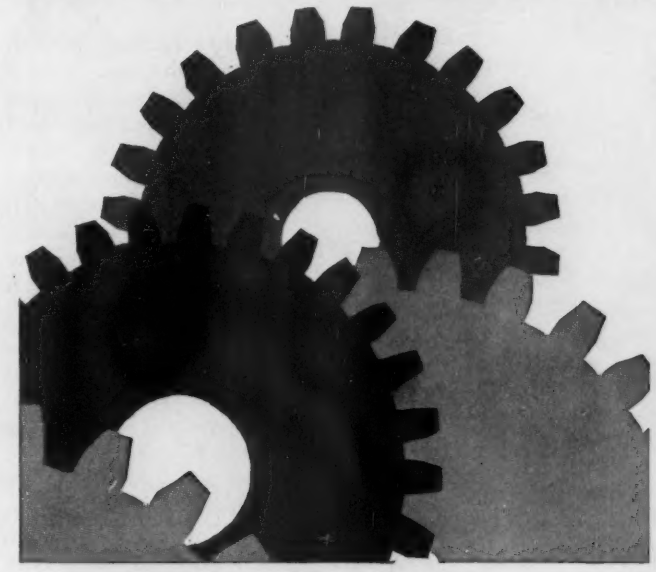

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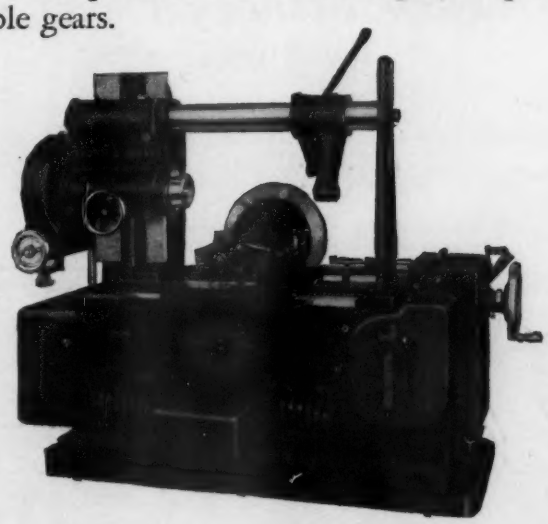

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SINCE 1864

Potash

(*Continued from page 95*)

every minute of the year the plant will receive about four tons of brine from the lake, will separate over two and one-half tons of water from the brine, will separate about a ton of undesired salts and will turn out over 500 pounds of marketable potash and borax. . . . Its large production enables this plant to compete on potash in the markets of the United States and of the Orient, and to compete on borax in the markets of the whole world. . . . Although the output of this plant is fairly large, there is no reason to think that it has begun to approach its limit. . . .

"This immense production of potash has removed all danger that the United States may ever suffer from a potash famine. . . . In time of stress it would be easily possible within a year to build plants on this one lake that would supply all the potash that we need.

"We are now using only 250,000 to 300,000 tons of K_2O a year. We could probably use two or three times that much to good advantage. . . . With proper education of the consumer in the use of potash our imports of it from Germany and France should increase rather than decrease for years to come."

Two other companies at Searles Lake are now showing more activity but neither may as yet be said to have made commercial potash.

The roseate picture presented by Teeple needs some qualification. The estimated reserves of K_2O at Searles Lake are about 20,000,000 short tons, a quantity sufficient to last this country nearly 100 years at the present rate of consumption, but if that rate should be increased as Teeple suggests the life of the available supply would be correspondingly shortened. Moreover, the manufacture of potash at Searles Lake is conditioned in part at least by the ability of the company to make and sell borax and possibly other by-products. Searles Lake is remote from most of the areas where potash is consumed. Other sources of supply are therefore highly desirable.

Other Sources

The other existing plants at which potash is now being produced as a by-product are not likely to enlarge their business sufficiently to cause any great increase in the amount of potash that they can supply. If, therefore, a potash industry is to be established in America on a scale to threaten seriously the domination of the foreign monopoly, other natural sources must be looked for which may either furnish potash salts as an abundant and cheap by-product or yield the potash salts themselves in sufficient quantity and cheaply enough to compete with foreign potash. The two sources that now appear of greatest interest in these respects are the greensand marls of New Jersey and Delaware and the bedded potash salts of the Permian salt basin of the southwest.

Greensand Marl

The potash content of greensand marl (glauconite) is relatively low, about six to eight per cent, but greensand is so accessible to transportation and to markets, so easily minable by steam shovel methods, and so susceptible to extraction that its exploitation offers many attractive possibilities. During the World War many attempts were made to produce potash from greensand and one of them had made considerable headway by the time the armistice was signed. This was the Charlton process, which as elaborated by Shreve,* employs lime and water with green sand in a digester at a temperature of about 470 degrees

*Shreve, R. Norris, The action of lime on greensand: Jour. Ind. and Eng. Chem., vol. 13, No. 8, p. 693, Aug. 1921.

(*Continued on page 122*)

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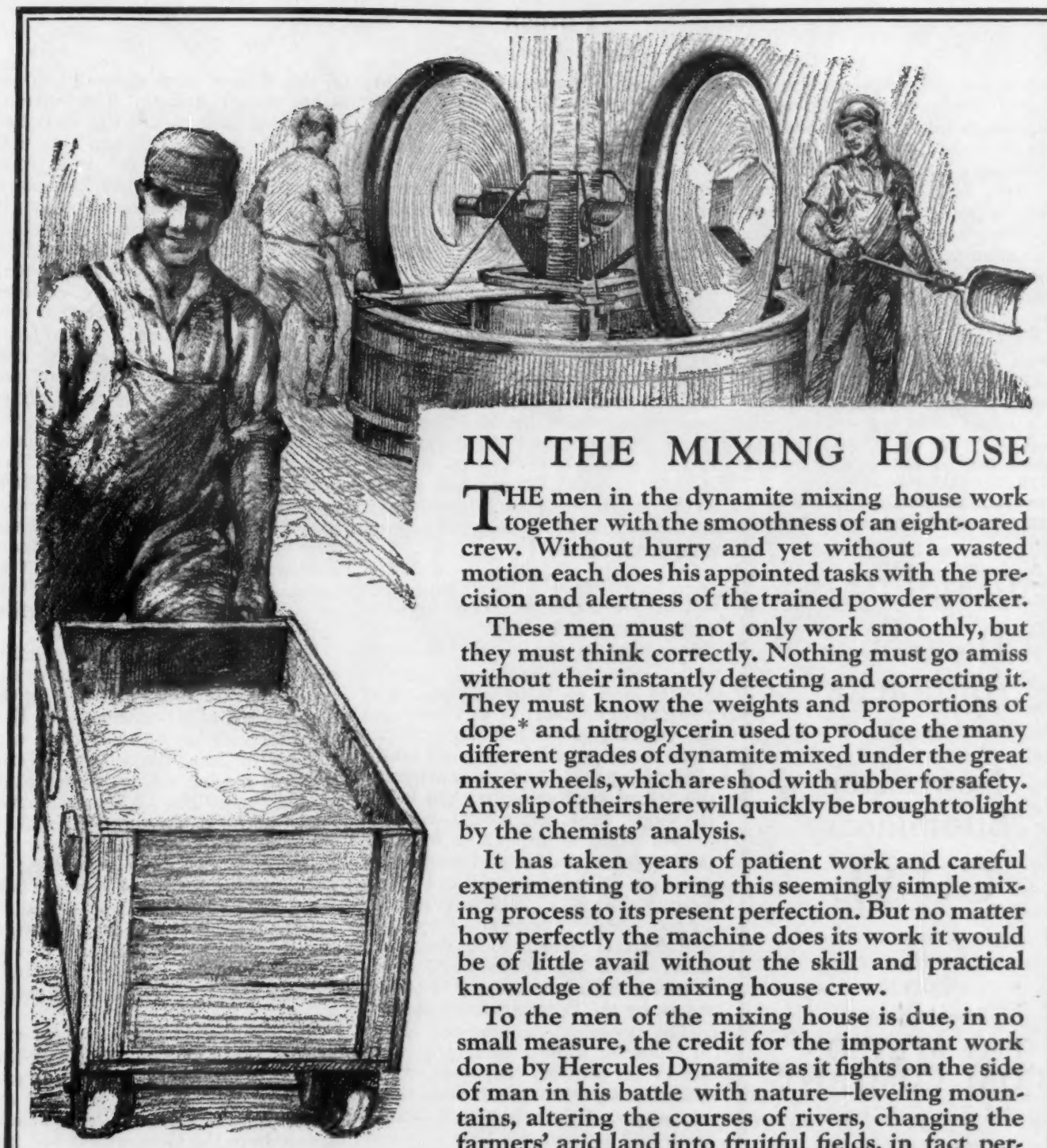

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*"Dope"—the powder makers' term for an absorbent containing proper proportions of nitrate of soda, nitrate of ammonia, wood pulp, flour, starch, sulphur, chalk, and other ingredients and which by their own combustion furnish explosive energy.

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Potash

(*Continued from page 120*)

Fahrenheit and under a pressure somewhat over 500 pounds. The chief reaction which takes place is that of lime on greensand which on the one hand liberates the potash in a very pure caustic form and on the other produces a material high in lime, which possesses valuable cementitious and liming properties.

Later research on utilization of greensand has been conducted by the Bureau of Soils and independently along similar lines by A. J. Moxham at Odessa, Delaware. By the Moxham process, according to Turrentine,* greensand without preliminary treatment is mixed with hot, dilute, sulphuric acid. The reaction starts at a temperature of about 85 to 90 degrees Centegrade, attained merely by the dilution of the acid with water and the heat of the reaction of the acid on the greensand, and is complete in five or six hours. The resulting materials are iron oxide, ochers, alum, aluminum sulphate, alumina, potassium sulphate, "glaucosil" and fuming or other sulphuric acids. Glaucosil, the granular siliceous residue from the original acid treatment of the greensand, possesses highly adsorptive qualities, which would render it useful as a decolorizing and purifying agent. Since glaucosil constitutes about 50 per cent of the original greensand, both the commercial success of the process and the quantity of potash which it may supply to the American market depend largely on the market which glaucosil may be able to command.

*Turrentine, J. W., Potash from Greensand (Glauconite), Jour. Ind. and Eng. Chem., vol. 17, No. 11, pp. 1177–1811, Nov. 1925.

Permian Salt Basin

The Permian salt basin extends from central Kansas southwestward through the panhandle section of Oklahoma and Texas into southeastern New Mexico and southwest Texas. The great accumulations of salt here and the general geological similarity of this basin to the potash-bearing salt basins of Germany and Alsace early attracted the attention of geologists and led to the hope that commercial beds of potash might ultimately be found in this region. Udden's discovery of potash in brine from a well in Dickens County, Texas, in 1912 was followed by coöperative investigations by State and Federal Geological Surveys and later, when the State Survey was forced to withdraw because of lack of funds, by the Federal Suryey alone.

The investigation consisted chiefly in following wildcat drilling developments in territory supposed to be underlain by Permian salt beds, securing samples of the salts penetrated and analyzing the samples thus obtained. The coöperation of the drilling companies was necessary to the prosecution of the work and was usually freely accorded though the interests of the drillers were generally in oil rather than in potash. The Government itself drilled a test well in Potter County in 1916. Although this well was located between two wells relatively nearby, each of which had shown evidence of the presence of potash, it proved practically barren. An actual potash salt, polyhalite, was identified in well cuttings in Texas region about 1920. Somewhat later in cuttings from New Mexico, the mineral sylvite (KCl) was recognized. Meanwhile public interest in the exploration had become so widespread that a law was passed (Public Number 424, Sixty-Ninth Congress approved June 25, 1926) authorizing an annual appropriation of $100,000 for a period of five years for joint potash investigations by the Departments of the Interior and of Commerce. Drilling operations were specifically provided for but under conditions which made it difficult to carry out the intent of the law. These objectionable provisions were ameliorated by subsequent amendment.*

The Geological Survey representing the Department of the Interior and the Bureau of Mines representing the Department of Commerce have thus been carrying on a campaign of core drilling in New Mexico and Texas which is nearing the completion of its second year. The Geological Survey is selecting the drilling sites, making the necessary analyses and tests and announcing the findings relating to potash. The Bureau of Mines is handling the necessary contracts, conducting the drilling operations and beginning a series of technological investigations to devise methods of mining, extraction and refinement of the potash salts.

Seven holes have already been completed, three in Eddy County, New Mexico, and four in Texas (one each in Ector and Crockett counties and two in Upton County). Figure 1 shows a core from the Government test hole No. 1, Eddy County, New Mexico.

*Public No. 759, Sixty-Ninth Congress, approved March 3, 1927.

(*Continued on page 124*)

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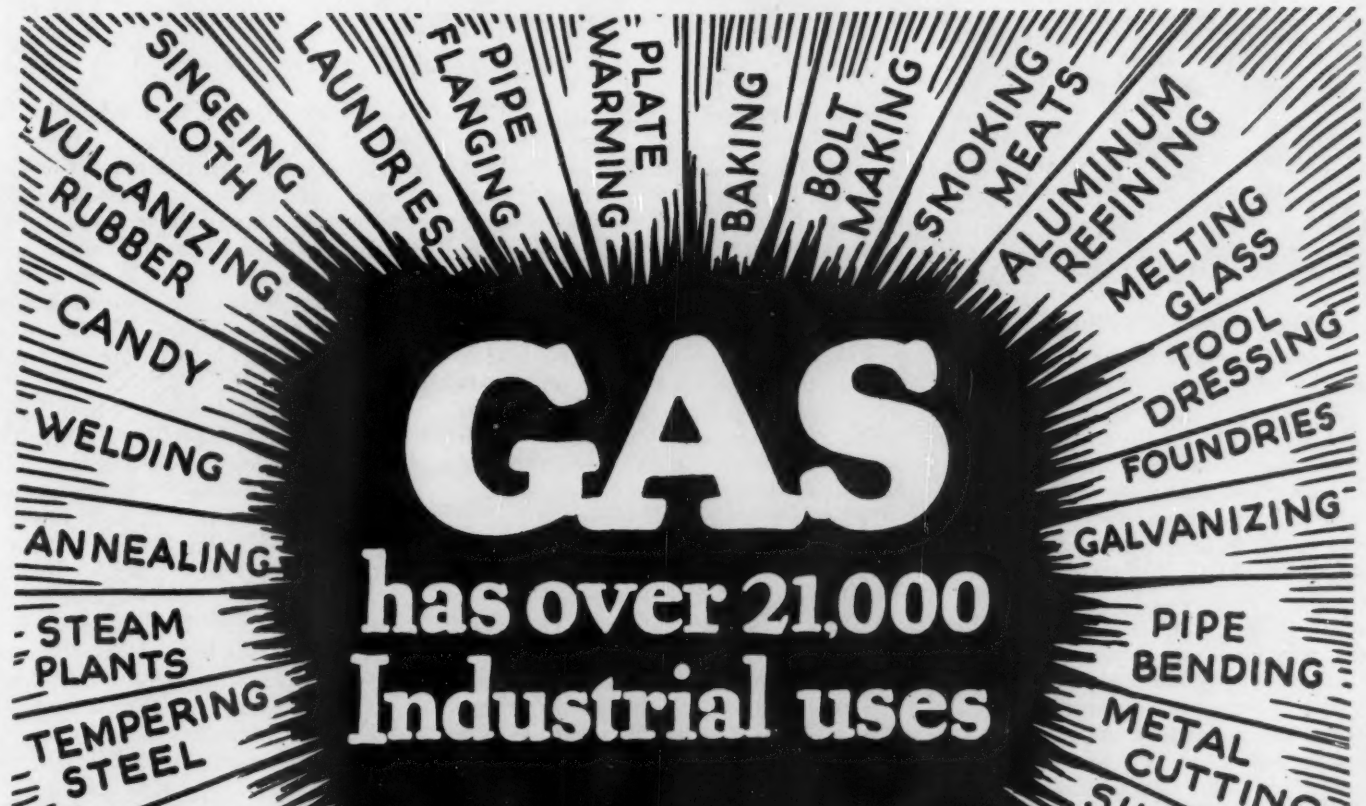

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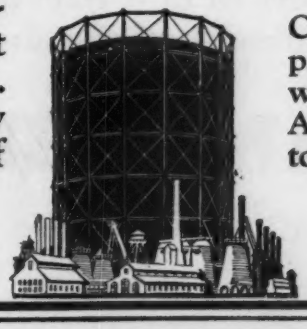

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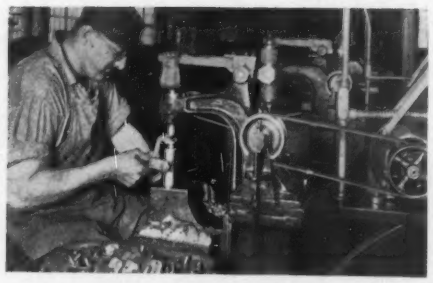

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Knife handles, shovels, built-up wheels, roller chains, automobile ignition parts, hardware, cutting pliers, wrenches, toys, roller bearings, kitchenware, and fish line reels.

Potash

(*Continued from page 122*)

Note the effect of drilling the solution on the carnellite bed near the top. An eighth hole to be drilled in Crockett County, Texas, has also been contracted for. Three of these have already been studied and reported in the public press. In addition to the coring done by the Government several oil companies have made core tests for potash in connection with their search for oil, and two companies, one operating in New Mexico and the other in Texas, have made core tests with special reference to the possibility of exploiting the potash commercially.

The net result of these activities has been that six potash minerals found in the German or Alsatian potash fields have been recognized in the New Mexico-Texas potash field. These are polyhalite (several colors and textures), sylvite, carnallite, kainite, langbeinite and leonite. Besides these several related salts common in the European potash fields, namely, kieserite, magnesite and bischofite have already been found. The finding of these minerals strengthens the geologic resemblance already noted between the Permian salt basin of Texas and New Mexico and the German and Alsatian potash fields. Polyhalite in beds, blebs, and disseminated masses is the most abundant of the potash minerals thus far recognized. Substantial masses of this mineral of grade comparable with salts mined abroad have been found in two localities in New Mexico, and have been announced. Work chiefly by private companies indicates that relatively large bodies of the more acceptable chloride salts are probably also present.

The investigations above mentioned have progressed little beyond the initial stage so far as finding out the character and amount of the probable potash reserves in the Permian salt basin is concerned. Nevertheless the pertinent inquiry whether any salts so located can be produced and marketed in competition with foreign potash is being raised and at least one private company operating in New Mexico is earnestly engaged in the attempt to solve the problem.

One thing seems certain. America has abundant resources of potash-bearing materials. The researches already carried on make it clear that the threat of a potash famine through the shutting out of foreign supplies, which became so serious during the World War, need never occur again.

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Export Representative: U. S. Steel Products Co., New York

Pacific Coast Representative: U. S. Steel Products Company, San Francisco, Los Angeles, Portland, Seattle

On your first trip abroad, you are doubtless prepared to see lots of interesting things—icebergs, perhaps—exclusive French restaurants serving corned beef and cabbage—cultured Englishmen who do not wear monocles, or say "Old Bean". Probably you would not even register surprise if you found high speed Otis elevators apparently as much at home on the Leviathan and other trans-atlantic liners, as in the finest buildings in all parts of the world.

OTIS ELEVATOR COMPANY

Offices in All Principal Cities of the World

Automobile Assembling

(*Continued from page 98*)

chain conveyors, is driven through a 5 h.p., 1,200 r.p.m. motor, the necessary speed reduction being accomplished through a chain drive, a set of bevel gears and a mill type, spur gear reducer, ratio 36 to 1. Square jaw clutches make it possible to cut out any conveyor desired. A breaking pin in the coupling between the reducer and main line shaft protects the equipment from any serious breakdown.

After the wheels follows the radiator, which is delivered from a mezzanine floor by means of a gravity roller belt conveyor, foot brake operated to control speed. The side apron, running board and front fender are put together as a subassembly on a mezzanine floor and lowered by hand to the line. Many other parts follow as the chassis is brought up to the body drop.

At the time the motor is added to the chassis on the line, the key number, frame number, motor number, transmission number, starter number, generator number, front axle number, and rear axle number are recorded and sent to the record office through a pneumatic tube. There, the numbers are recorded, packing slip made out and delivered to the clerk at the body drop. This clerk adds the body number to the slip and checks the other part numbers. One copy of this record travels with the car, the other copies are returned to the record office. In this manner, complete records of the cars are obtained before they leave the assembly line.

The fourth assembly starts with the body drop. Fig. 13 shows the three jib cranes, each equipped with a 17-inch diameter, 4-foot stroke, 6 to 1 ratio air hoist which lowers the bodies to the assembly line (Fig. 14). Rear fenders are next in order, they being lowered by gravity (Fig. 14), controlled by a foot-operated brake. Other parts follow up to Fig. 15, where gasoline becomes the motive power, and finally the lights are adjusted (Fig. 16), when the automobile is complete and ready for shipment.

STANDARD
INSTRUMENTS
OF PRECISION

C. L. Berger & Sons, Inc.
Established 1871
37 Williams St., Boston 19, Mass.

Plant Research

(*Continued from page 108*)

life history, for day-length periods of 5 to 24 hours in each 24-hour day. The remaining time they were kept in the adjoining dark room at the same temperature and humidity.

It was found that plants do not all respond alike to environmental factors. Some plants, such as red clover, buckwheat, and many of the grains, grow well under continuous illumination. They will in general grow about equally well on an 18 to 19-hour day. Other plants such as the tomato can not be forced so far, as they will not withstand continuous illumination. The tomato requires a rest period of about six hours in each twenty-four. Many plants, especially annuals, can be grown from seed to flower in a relatively short time, if given additional light, a high temperature, and extra amounts of CO_2. Spring wheat, oats and barley were grown from seed to ripening grain in about forty-five days, crops which require three to four months under our present system of agriculture. A crop of red clover hay was grown from seed in about sixty days. This plant requires in nature two seasons growth. The life history of a number of plants can be greatly shortened by controlling the environment, and their growth rate increases with day length up to 19–24 hours.

The relation of day length to flowering in a number of plants holds true for artificial light as well as daylight. Short day plants such as salvia and cosmos which naturally flower in the fall, winter, or spring, flower under artificial light on day lengths of five hours to twelve hours. Long day plants which normally flower in the summer, such as lettuce and radish, flower only on day lengths greater than twelve hours. If production of head lettuce is desired, therefore, it should be grown on a day length of twelve hours or less. Other plants such as buckwheat will flower on all day lengths from five to twenty-four hours. Illumination values of the order of 2–3-foot candles are often effective in forcing flower production in lettuce, as is the case with day lengths effects in general. On the other hand, if a great increase in dry weight of plant material produced is desired — an increase in photosynthesis, a much higher intensity is necessary—that is, illumination of the order of 400 to 1,200 foot candles.

THE TEST of an engineering plan is its adaptability to the purpose for which it was designed. Training for Institute work is an important engineering problem. The success of our many students after entering the Institute is due to their adaptability to Institute requirements and proves the thoroughness of our methods.

CHAUNCY HALL SCHOOL
554 Boylston Street, Boston, Massachusetts
FRANKLIN T. KURT, Principal

THE MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE, MASS.

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To be admitted to the first year class applicants must have attained the age of seventeen years, and must satisfactorily fulfill entrance requirements in Algebra, Plane and Solid Geometry, Trigonometry, Physics, Chemistry, English, History and French or German and two units of elective subjects. Examinations are required in all subjects except Chemistry, History and the electives, the requirements for which are fulfilled by the presentation of satisfactory certificates. A division of these entrance subjects between different examination periods is permitted.

Entrance examinations are held at the Institute in September. In June applicants will be examined by the College Entrance Examination Board in Boston, New York, Philadelphia, Chicago and many other cities in America and Europe. A circular stating times and places is issued in advance by the College Board.

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Correspondence should be addressed to the Institute of Technology.

PUBLICATIONS

Catalogue: Bulletins of General Information, Summer Session, and Graduate Study and Research; and the Report of the President and the Treasurer.

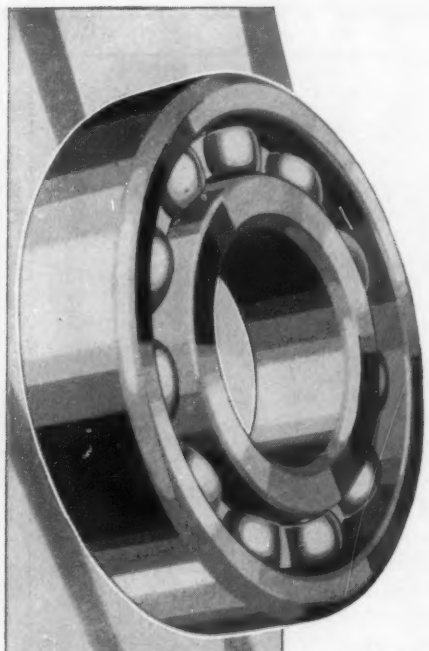
Any of the above named publications will be mailed free on application.

For information, address

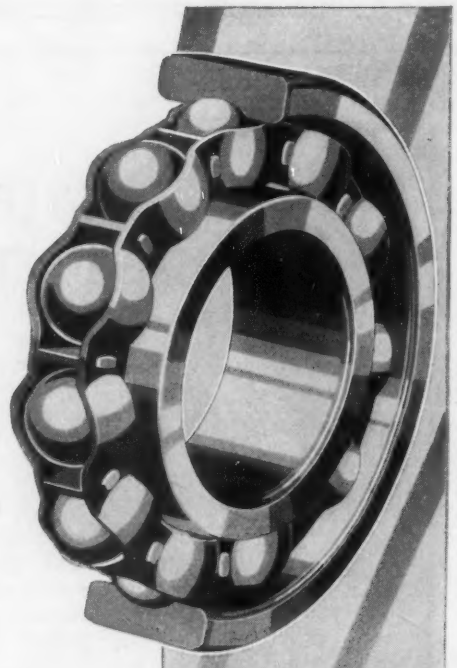
ADMISSIONS OFFICE

MASSACHUSETTS INSTITUTE OF TECHNOLOGY

CAMBRIDGE A, MASS.



WHAT TYPE OF BEARING WILL YOU FAVOR?



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923

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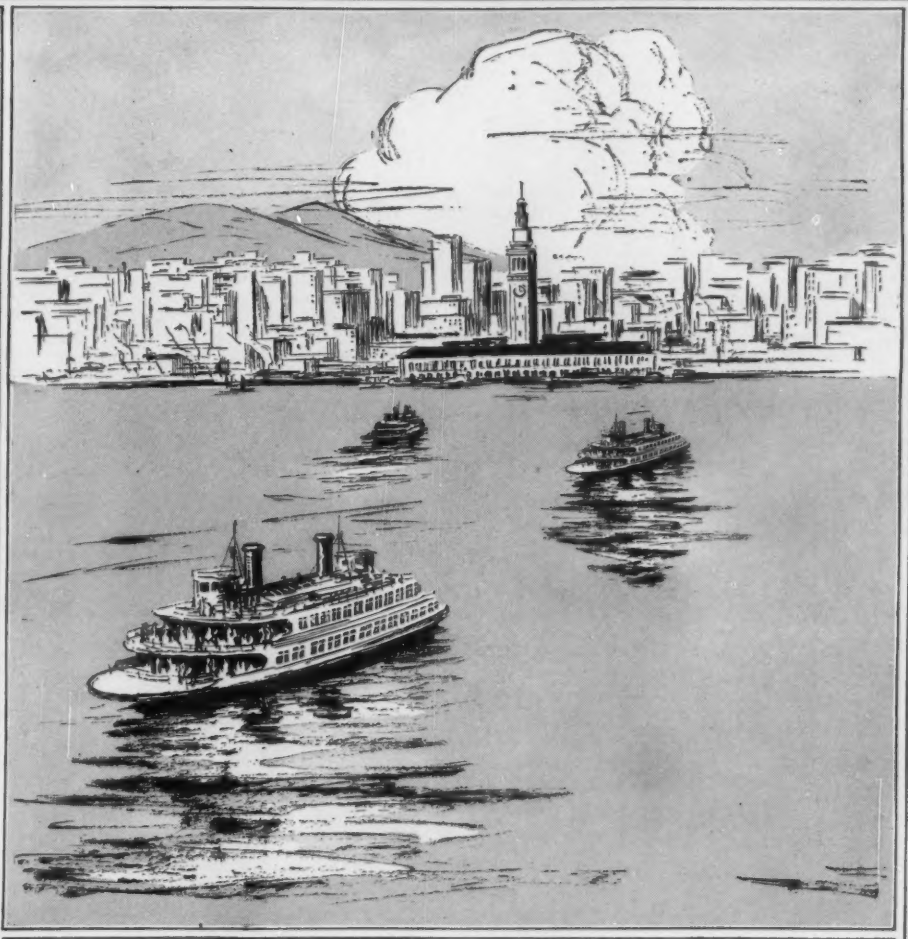

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